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UK Future Energy Scenarios

UK gas and electricity transmission

NOVEMBER 2011


ABERTHAW - PYLE

The UK Future Energy Scenarios Document is a new publication from National Grid. In this document we describe in some detail the assumptions behind the main scenarios used in our analysis and development of future energy scenarios: for example, developments in electricity generation backgrounds; electricity and gas use and progress against environmental targets.

The Ten Year Statement (TYS) and the Offshore Development Information Statement (ODIS) have historically contained material included in this document, but this publication is intended to provide a detailed description of scenarios and their underlying solutions. TYS and ODIS are therefore able to concentrate on the implications of the scenarios for the development of the gas and electricity networks.

This represents a new stage in our annual consultation process. Here we describe in detail the scenarios finalised in the first half of 2011 and presented to the industry at the Transporting Britain's Energy (TBE) event in July. Early in the New Year we will seek feedback on our scenarios in detail with the industry in an annual consultation, and views gathered in this exercise will inform the development of the 2012 scenario analysis.

I hope that you find this an informative and useful document and a worthwhile addition to our range of publications. I look forward to receiving your views, please contact Richard.Smith@ngrid.com

Richard Smith
Future Transmission Networks Manager

Executive summary

This document is a new addition to the National Grid suite of annual publications and describes the scenarios used in our annual planning processes. It covers material previously included in the Ten Year Statement (TYS) and the Offshore Development Information Statement (ODIS), but concentrates on the development of the scenarios and the assumptions behind them rather than the implications for the gas and electricity networks.

The UK has legislation in place setting limits on the emissions of greenhouse gases as far ahead as 2050. There is also legislation mandating a minimum level of renewable energy in 2020.

A single forecast of energy demand does not give a sufficiently rich picture of possible future developments so National Grid now carries out analysis based on three different scenarios.

- In the Slow Progression scenario developments in renewable and low carbon energy are comparatively slow, and emissions and renewable targets for 2020 are not met after 2025.
- In the Gone Green scenario the renewable target for 2020 and the emissions targets for 2020, 2030 and 2050 are all reached.
- The Accelerated Growth scenario uses the same view of energy demand as Gone Green but has faster development of offshore generation. All environmental targets are reached, earlier than the required dates.

The assumptions behind the scenarios are described in some detail out to 2030 in this document, including:

- The economic background;
- Fuel prices;
- Developments in the heating market, with particular emphasis on heat pumps;
- Developments in transport, with particular emphasis on electric vehicles;
- Electricity demand, with discussion of high efficiency technologies, especially lighting, and the application of smart technology for demand side management.

The power generation fleet in each scenario is selected to meet the peak demand with an adequate plant margin, but with different levels of low carbon and renewable capacity.

Having considered the energy demand for heat, transport and electricity, and the break-down of electricity generation by fuel type, the effect on total gas demand and gas supply is examined.

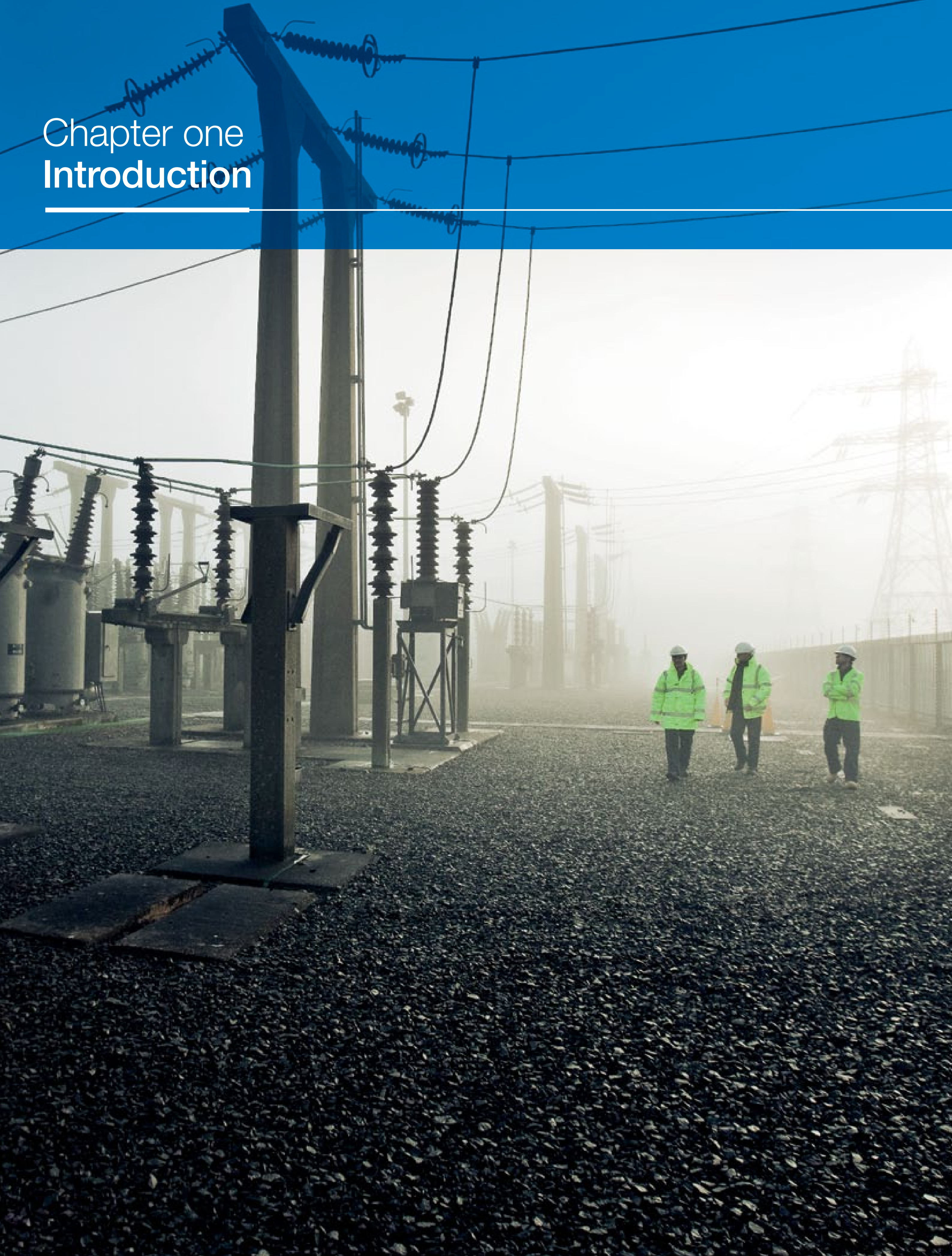
Developments from 2030 to 2050 are not considered in the same level of detail, but a brief description of the main demand sectors is given, along with the implications for electricity generation and gas demand.

Contents

The table below shows some of the key statistics for the Gone Green scenario.

	2020	**2030**
Total Energy Demand	1471TWh	1402TWh
Renewable	232TWh	474TWh
Renewable %	15% (Target 15%)	33% (No Target)
CO_2 emissions and reduction	355 MT CO_2 (-40%, target -37%)	228 MT CO_2 (-62%, target -60%)

Chapter one
Introduction



This document describes the assumptions behind all three scenarios, looks at the resulting energy demand, and for Gone Green, examines the CO_2 emissions and renewable energy levels.

Traditionally National Grid has produced a single forecast of gas and electricity demand based on analysis of history and views of the future incorporating forecasts of economic growth, industry intelligence about new developments, new technologies and new connections to the gas and electricity networks. This approach has served the industry well but does not now give a sufficiently rich picture of possible futures which is needed in addressing the challenges facing the energy industry in adapting to climate change.

In place of the traditional forecasts National Grid now uses scenarios representing different views of the future. The Gone Green scenario represents a future in which the renewable energy target for 2020 and CO_2 reduction targets for 2020, 2030 and 2050 are all met.

The Slow Progression scenario is more akin to the traditional forecast of previous years. Under this scenario the first environmental targets are achieved a few years later than in Gone Green, in 2026. The Accelerated Growth scenario uses the same demand as Gone Green but has a faster development of offshore generation. The 2011 editions of Gone Green, Slow Progression and Accelerated Growth as described in this document were included in the Offshore Development Information Statement (ODIS) published in September 2011. Gone Green and Slow Progression will be included in the Ten Year Statement due to be published in December 2011.

It is important to remember that these are scenarios, not forecasts. It is possible to prepare forecasts for the next few years in stable market conditions but unforeseen events, such as the recent recession or the introduction of new Government initiatives, make forecasting several years ahead increasingly difficult. Gone Green represents a balanced approach to meeting environmental targets, with contributions from the heat, transport and electricity generation sectors. It is by no means the only means of reaching the targets, and there is limited cost minimisation in the modelling so there may be cheaper solutions, but it is a scenario which does not require extreme efforts from any one sector in isolation.

This document describes the assumptions behind all three scenarios, looks at the resulting energy demand, and for Gone Green, examines the CO_2 emissions and renewable energy levels. Projections to 2030 are discussed in considerable detail, whilst the period 2030 to 2050 is described in more qualitative fashion.

Detailed tables of gas demand for Slow Progression and Gone Green, and electricity demand for all three scenarios are available on the National Grid web site[1], and a summary of the key facts and figures from Gone Green is available in the appendix to this document.

1 www.nationalgrid.com/uk/Gas/OperationalInfo/TBE/docs/

Chapter two
Now – 2030

The period from now to 2030 is covered by legislation on renewable energy and carbon emissions. Government and EU targets require that by 2020 15% of all energy will come from renewable sources[2], with the Government's Renewable Energy Strategy lead scenario[3] suggesting that the 15% renewable target could be met by a 30% renewable contribution in the electricity generation market, 12% renewable contribution from heat generation, and 10% renewable contribution from Transport. A series of four carbon budgets, set by the Committee on Climate Change (CCC) and subsequently adopted by the Government, call for carbon emissions to be reduced by 37% compared to 1990 level by 2020 and 60% by 2030[4,5].

In order to capture this level of detail in our scenarios the period to 2030 is modelled in considerably more detail than the following 20 years.

This chapter contains descriptions of the main features of our three scenarios, followed by details of the main drivers, namely the economic background, the demand for heat, for transport and for electricity, and finally the implications for electricity generation, gas demand and gas supply.

2 www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/res/res.aspx
3 www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Renewable%20energy/Renewable%20Energy%20Strategy/1_20090715120255_e_@@_TheUKRenewableEnergyStrategyExecutiveSummary.pdf
4 http://www.decc.gov.uk/en/content/cms/legislation/cc_act_08/cc_act_08.aspx
5 The CCC budgets set targets in the form of total emissions over a period of years, but these equate to the 37% and 60% reductions used here.

2.1
Description of scenarios

2.1.1
Gone Green

Gone Green is constructed in such a fashion that the renewable energy and carbon emissions targets are always achieved. Analysis is carried out in four sectors, Residential, 'Service' (equivalent to the Digest of UK Energy Statistics (DUKES)[6] categories Public Administration and Commercial), Industry and Transport and uses a bottom-up approach that starts at the finest level of detail practical.

For example, within the residential sector, final energy demand is considered at household level for space heating, water heating, cooking and electrical appliances, including lighting. Within each end use category the market share taken by different fuel types is considered, and the demand for fuel calculated from the end use energy demand and the appliance efficiency.

Aggregated fuel demand in each sector is validated against DUKES for historical years. Fuel demand for future years is calculated using assumptions on final energy demand, due, for example, to improved insulation or changes in economic conditions; improved appliance efficiency; and change in market share, for example due to the increased take up of heat pumps. Demand for each fuel type is then aggregated across all sectors, and adjustments are made for loses in transmission and distribution.

The annual electricity demand is converted to a peak demand using analysis that is initially consistent with recent history, but changes later in the scenario period to reflect the potential impact on peak demand of greater demand side management and smart grid technologies. Power generation capacity appropriate to the level of peak demand is then selected, and generation by fuel type is calculated.

Finally, the total requirement for each fuel type is aggregated and the CO_2 emissions and proportion of renewable energy are calculated.

The total UK energy requirement in Gone Green and progress against targets are shown in Figure 1 and Figure 2.

A summary table of key facts from the Gone Green scenario is available in the appendix to this document.

6 www.decc.gov.uk/en/content/cms/statistics/publications/dukes/dukes.aspx

As an aid to navigation section, headings are colour coded for our three scenarios, **Gone Green**, **Slow Progression** and **Accelerated Growth**.

Figure 1.
Total UK energy requirement: Gone Green

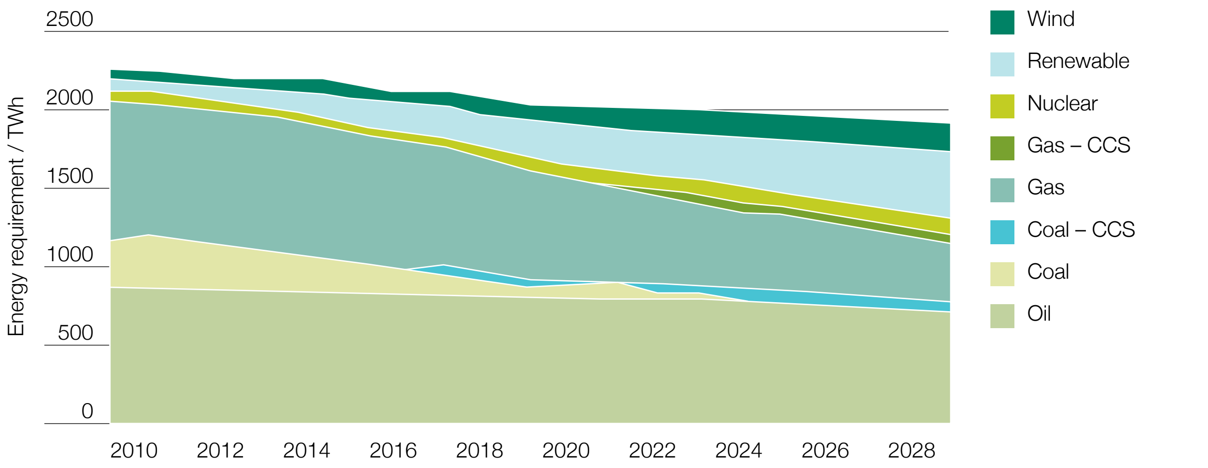
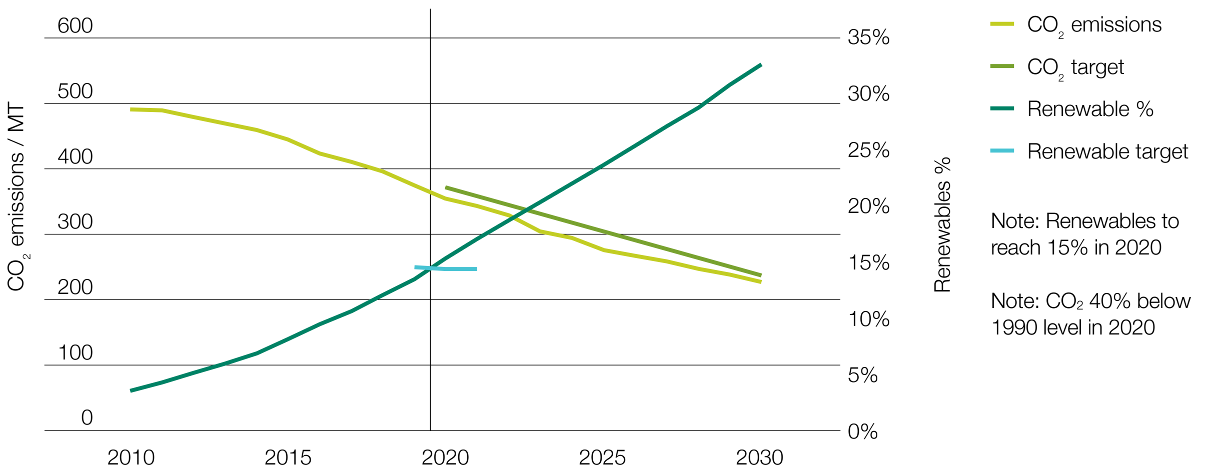


Figure 2.
CO_2 emissions and percentage of renewable energy



2.1.2
Slow Progression

The Slow Progression scenario is similar in concept to the forecasts of earlier years. Projections are prepared for gas demand and electricity demand on the National Grid transmission networks.

In contrast to the bottom-up approach used in Gone Green, Slow Progression uses econometric modelling at a sector level for both gas and electricity projections. Demand is related to a number of factors, including fuel price, economic growth and number of houses. Adjustments are made for increased levels of insulation and appliance efficiency.

The gas market is separated into demand within the Gas Distribution Networks (DNs) and demand at sites connected directly to the National Transmission System (NTS). The DN market is segmented by size of customer rather than by customer type but as a good approximation, demand in the Non Daily Metered (NDM) 0 - 73.2 MWh/yr sector can be considered to be residential, demand in the 73.2 – 732 MWh/yr sector is commercial and the remaining DN demand is split 50:50 between commercial and industrial. There are comparatively few NTS customers so these can all be forecast individually.

Projections for electricity demand are made for domestic, commercial and industrial categories.

Forecasts are not made for other fuels except insofar as they affect gas or electricity demand; for example, lower coal prices will lead to higher coal use and less gas in electricity generation. There is no full work up of fuel use, CO_2 emissions or renewable energy use at UK level in the same way as in Gone Green, but indicative calculations show that the 2020 emissions target will not be reached until 2026.

One important difference to note is that Slow Progression projections are for GB only rather than UK. In Gone Green, modelling is all at UK level and results for National Grid's gas and electricity networks have to be extracted from the whole. In Slow Progression, modelling is all at the level of National Grid's gas and electricity networks, and results for UK have to be created by adding in data for Northern Ireland and for energy that does not flow through our networks.

In Slow Progression, modelling is all at the level of National Grid's gas and electricity networks, and results for UK have to be created by adding in data for Northern Ireland and for energy that does not flow through our networks.

2.1.3
Accelerated growth

Accelerated Growth uses the same projections of demand as Gone Green but assumes that offshore generation builds up far more quickly. The additional renewable generation capacity means that there is no requirement for an extra life extension for nuclear AGR plant as is the case in Gone Green. Renewable and carbon emission targets are met earlier in Accelerated Growth than in Gone Green.

2.2
Economic background

2.2.1
Slow Progression Economics

Economic recovery is expected to be moderate, with fiscal austerity acting as a drag on the positive impact of stronger exports. GDP is expected to grow by 1.7% in 2011, returning consistently to the historic trend rate of around 2.5% pa only in 2017. Annual GDP growth averages 2.3% over the period 2011 to 2026 inclusive.

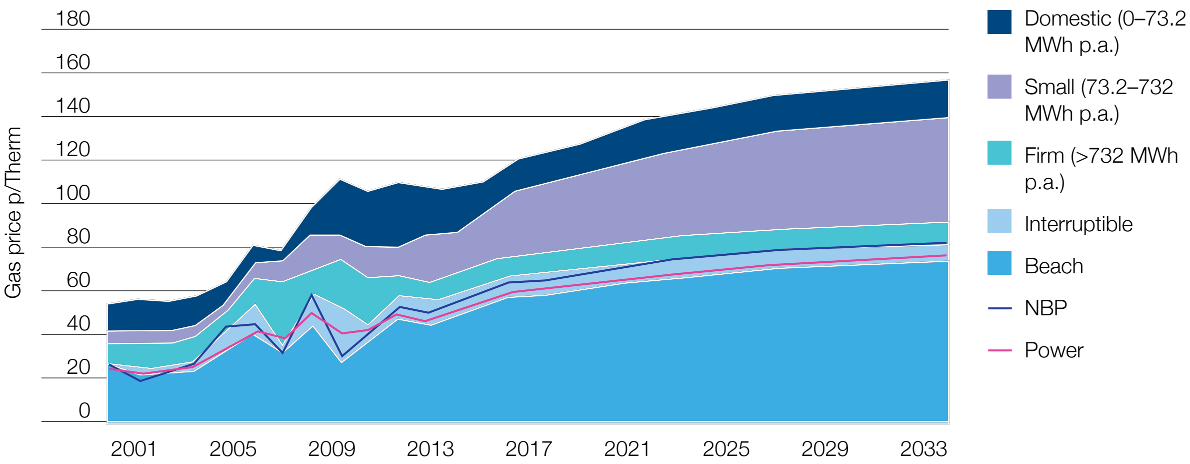
Manufacturing output suffered particularly badly due to the recession, contracting by 10.7% in 2009, though it recovered in 2010, growing by 3.6%. Manufacturing output is expected to grow by 3.7% over 2011. Annual manufacturing output growth is expected to average 1.6% over the period 2011 to 2026 inclusive.

Non-manufacturing output contracted by 3.8% in 2009 but recovered to grow by 1.1% in 2010 and is expected to grow by 1.6% in 2011. Annual non-manufacturing output growth is expected to average 2.4% over the period 2011 to 2026 inclusive.

Household disposable income grew in real terms by 1.2% in 2009, supported by the previous government's fiscal stimulus. However, real household disposable income contracted by 0.8% in 2010. Household disposable income is expected to continue to contract in 2011, by 0.3% in real terms. Annual real household disposable income growth is expected to average 2.0% over the period 2011 to 2026 inclusive.

Both Gone Green and Slow Progression make use of economic forecasts provided to National Grid by Experian Business Strategies. These date from early 2011, before the recent downturn in the economy.

Figure 3.
Forecast gas prices



Gas prices

UK gas prices are assumed to increase slowly throughout the forecast period, but remain between low US and high European Continental prices. For supplies from the Continent, oil indexation remains, though sales of spot gas continue to increase. Beyond 2022 the forecast assumes a slight drop in oil linkage, as non-OECD demand starts to reduce.

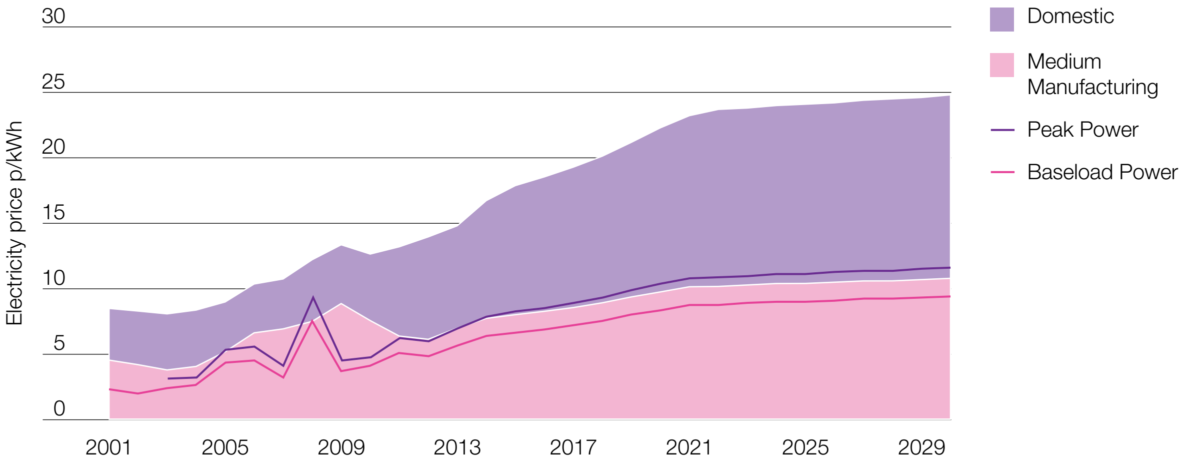
Domestic gas prices are forecast to increase slightly more than NBP[7] prices due to energy efficiency targets imposed on domestic gas suppliers, such as the Carbon Emissions Reduction Target (CERT) and the new Energy Company Obligation (ECO)[8].

7 National Balancing Point. A notional point which represent the NTS for balancing puposes and the point at which gas is traded.

8 www.decc.gov.uk/en/content/cms/news/pn11_37/pn11_37.aspx

Economic background

Figure 4.
Forecast electricity prices



Electricity prices

Wholesale electricity prices are assumed to continue to track gas prices, with the proportion of gas-fired generation remaining high for the majority of the forecast period. Additional factors that may affect the price of power include:

- Increasing costs of carbon during phase 3 of the EU Emissions Trading Scheme (ETS);
- Tightening plant margins, compared to today, as plant closes due to the Large Combustion Plant Directive (LCPD);
- Lower coal prices, in response to lower coal demand following the LCPD closures
- Increasing levels of higher cost low carbon generation.

Domestic electric prices are assumed to track the wholesale price with an allowance for the increasing cost of energy efficiency targets imposed on suppliers[8].

Relative Fuel Prices

Relative fuel prices have a huge impact on the power generation output mix and thus the level of gas demand from the power generation sector. In the Slow Progression scenario it is broadly assumed that there is a balance between gas and coal generation with gas-fired generation being generally more profitable for half of the year and coal-fired generation being generally more profitable for the winter period. Plant efficiency, age and historical running patterns are also considered and the output takes into account the limited running hours available to the coal plant that has opted out of the Large Combustion Plant Directive (LCPD).

8 www.decc.gov.uk/en/content/cms/news/pn11_37/pn11_37.aspx

The bottom-up calculation of residential demand in Gone Green does not depend directly on economic forecasts other than for the growth in households.

2.2.2
Gone Green Economics

Residential

Gone Green uses Government statistics for the number of households in 2007[9] and then applies the growth rate provided by Experian. It is worth pointing out that this growth rate is somewhat slower than used in the DECC 2050 pathways analysis[10] so although the starting point is the same, DECC pathways has 5% more households than Gone Green by 2030, as shown in Figure 5.

Services, industry and power generation

The fundamental economic assumptions used are similar to those in Slow Progression, though interpretation and modelling differs between the two scenarios.

Gas prices

Incentives to meet environmental targets distort gas prices relative to renewables; at times of low wind gas prices are at a premium, so day to day price volatility is increased. For supplies from Continental Europe the oil indexation is eroded.

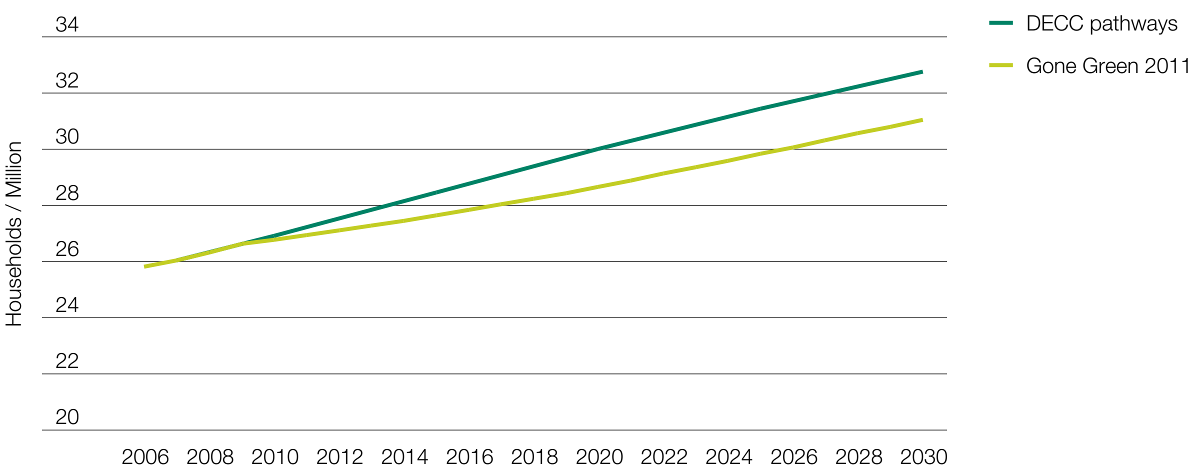
Relative fuel prices

As for Slow Progression, relative fuel prices are important for the power generation calculations. In the Gone Green scenario, in order to minimise carbon emissions, gas plant is assumed to run before coal plant for the whole year. The merit order in Gone Green is heavily based on carbon emissions, so although there are no specific price assumptions in this scenario, a relatively high carbon price would be a requisite of this merit order.

9 www.communities.gov.uk/housing/housingresearch/housingstatistics/housingstatisticsby/householdestimates/livetables-households/

10 www.decc.gov.uk/en/content/cms/tackling/2050/2050.aspx

Figure 5.
Projections of UK household numbers



2.3
Heat

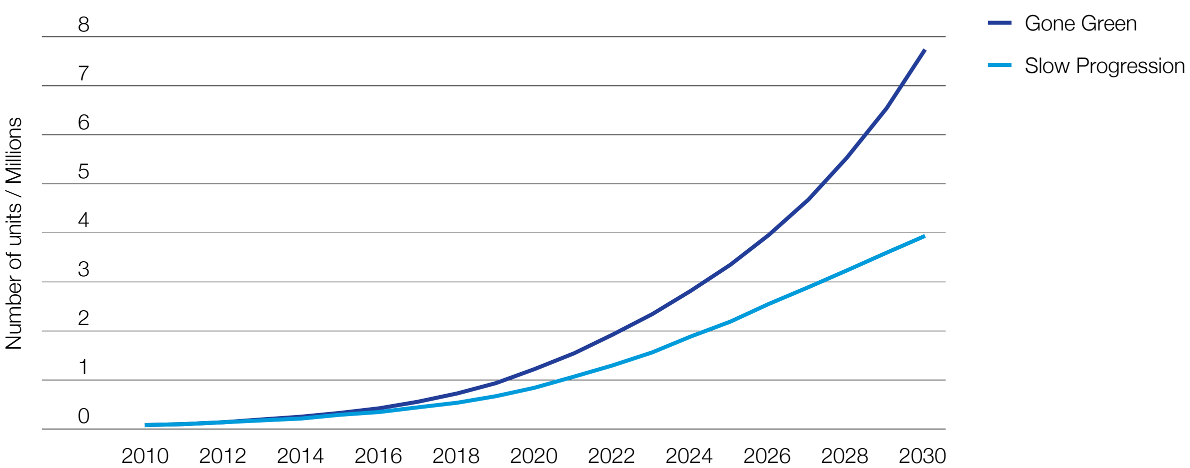
2.3.1
Heat Pumps

The adoption of heat pumps for domestic heating will be an important part of the effort required to meet environmental targets. Heat pumps are expected to attract support from the Renewable Heat Incentive (RHI): the premium payment is available to offset the cost of installation, but the level of support has not yet been finalised by the Government. As a result it is likely that the technology will be important in both the Slow Progression and Gone Green scenarios.

National Grid's projections for heat pumps in the residential market concentrate on air source rather than ground source units. Whilst ground source heat pumps are slightly more efficient than air source units, the extra work and cost involved in laying loops of piping in the ground suggests that the majority of installations will be air source. The market for gas absorption heat pumps is at a very early stage of its development in the UK so this technology has not been included in either Gone Green or Slow Progression, though it could play an important role in large or older houses where high costs of insulation make the installation of electric heat pumps unattractive.

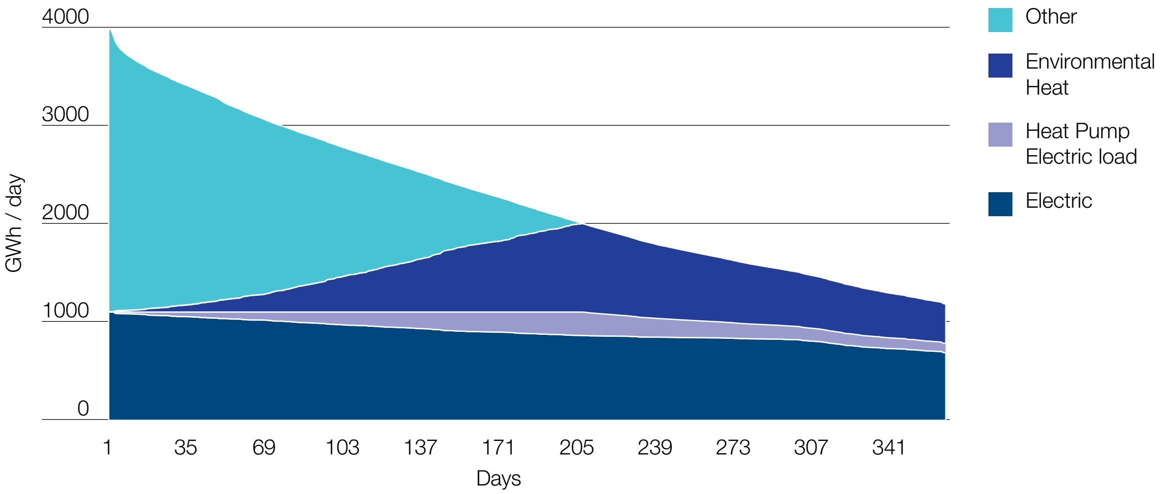
Data have been gathered from manufacturers and from trade bodies, and the projections have been benchmarked against values from DECC. The same analysis supports both scenarios but with different rates of deployment. Figure 6 shows the projected number of heat pumps in Gone Green and Slow Progression.

Figure 6.
Number of heat pumps in the residential market



Projections of heat demand in the residential sector in both Gone Green and Slow Progression depend strongly on levels of household insulation. Fuel use depends additionally on the efficiency of boilers and the market share taken by different fuels. The roll-out of heat pumps in this sector is of particular significance in meeting environmental targets.

Figure 7.
Electricity and heat load duration curves



Demand for heat is much 'peakier' than demand for electricity, as shown in the load duration curve in Figure 7. The bottom series shows demand for electricity excluding heating, which ranges from a maximum of 1110 GWh/day to a minimum of 690 GWh/day (62% of peak daily demand). The remaining series represent heating load, which ranges from a maximum of 3000 GWh/day to a minimum of 500 GWh/day (17% of peak daily heat demand). The 'other' series includes gas, biomass and, for houses not connected to the gas network, oil. As a result of the large range in the heat demand it will be very difficult to electrify the entire heat load.

Electric heat pumps can be used to supply around half the heat demand, represented by the middle two sectors on the chart, with little or no requirement for extra electricity generation capacity, but in order to satisfy the entire load it will be necessary to build between 100GW and 150 GW of new capacity, most of which will run for half the year or less, with correspondingly unfavourable economics. The upper limit of 150 GW assumes that at times of peak heat demand, when external temperatures will be low, the coefficient of performance of heat pumps will be close to 1, almost equivalent to electric resistive heating.

2.3.2
Slow Progression Heat

Gas demand within the gas distribution networks (DNs) is almost entirely for heat, though a small amount, less than 3% in 2010, is for power generation. As discussed in section 2.1.2, Slow Progression forecasts are based on econometric modelling rather than end use type, but for gas the market is driven almost entirely by heat demand.

Residential
Gas demand for heating falls until around 2020 due to increases in the energy efficiency in existing housing stock, resulting from thermal insulation improvements and increasing boiler efficiencies. Set against this are an increase in the number of households, and increasing comfort levels taken by consumers. Figure 8 shows the cumulative effect of these. Note that the loss in gas demand to the heat pump market is very small during this period as the majority of early installations are in properties not connected to the gas network.

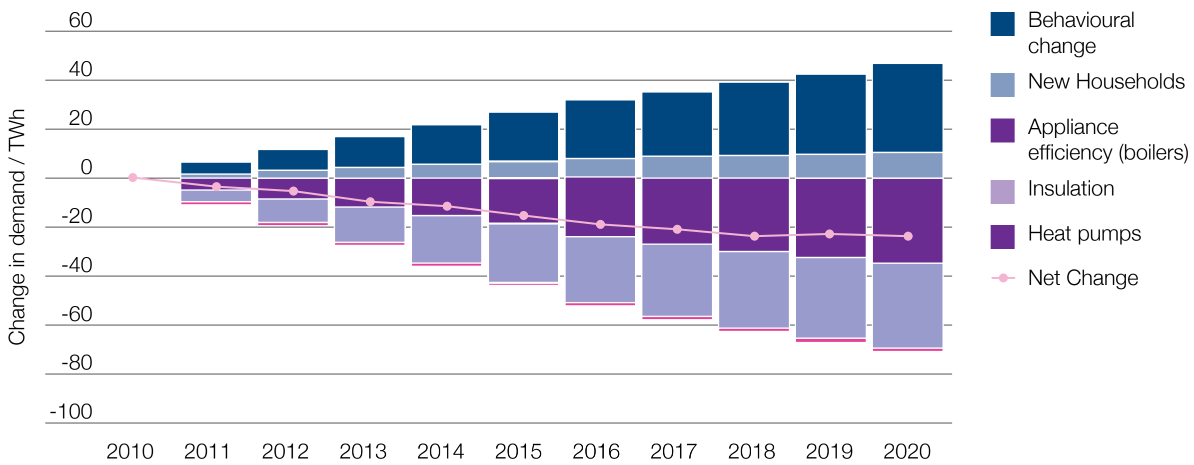
Beyond 2020 efficiency measures are approaching saturation and demand rises again as more new houses are built.

In the Slow Progression analysis, electricity for heating is included in domestic electricity use and is discussed in section 2.5.1.

Services and industrial
Demand is expected to fall over the period, though at a rate lower than in the recent past. The sector has contracted over recent years and difficult economic conditions have driven efficiency measures, but these cannot continue indefinitely at the same rate. The effect of the Carbon Reduction Commitment[11] is included but is assumed to have a fairly minor impact.

11 The CRC is a mandatory scheme aimed at improving energy efficiency and cutting emissions in large public and private sector organisations www.decc.gov.uk/en/content/cms/emissions/crc_efficiency/crc_efficiency.aspx

Figure 8.
Changes in residential gas demand: Slow Progression



CHP

CHP has not reached the targets set by the previous government for 2010 and is not expected to increase dramatically in Slow Progression. A number of the largest industrial sites connected to the NTS include CHP plant, and there are also some NTS power generation CHP sites where the primary purpose is generation of electricity for sale but where good use is also made of the waste heat. Although there are some new large schemes, most significant of which is the Isle of Grain CHP, the development of large gas-fired schemes is currently limited, so no significant growth in this area is forecast. Growth in medium and smaller scale gas-fired CHP has been assumed to continue in line with historical trends.

Whilst the gas-fired CHP market is not expected to grow significantly, the market for biomass CHP is likely to increase. A number of large scale biomass CHP projects are under discussion, some of which are included in the Slow Progression generation background.

2.3.3
Gone Green Heat

Residential
Gone Green assumes fairly rapid progress is made with installation of cavity wall and loft insulation in suitable properties due to an assumed higher price of energy and short pay back periods. The installation rate is in line with DECC's estimates from 2007-2010[12] with an average of 500,000 cavity wall and 800,000 loft insulations each year between now and the early 2020s with installation slowing down as market saturation is approached.

For properties without cavity walls there are assumed to be 20,000 installations of solid wall insulation each year between now and the early 2020s. Some increase is expected after this date as more cost-effective technologies are developed and market players in the insulation industry switch to solid wall insulation as the cavity wall and loft insulation markets decline having reached saturation. New build properties are assumed to be zero carbon from 2016[13].

These factors are combined to produce a heat loss co-efficient for an average property to fall from 250 Watts/°C to 170 Watts/°C by 2030. Overall, improved insulation saves some 56 TWh in 2030.

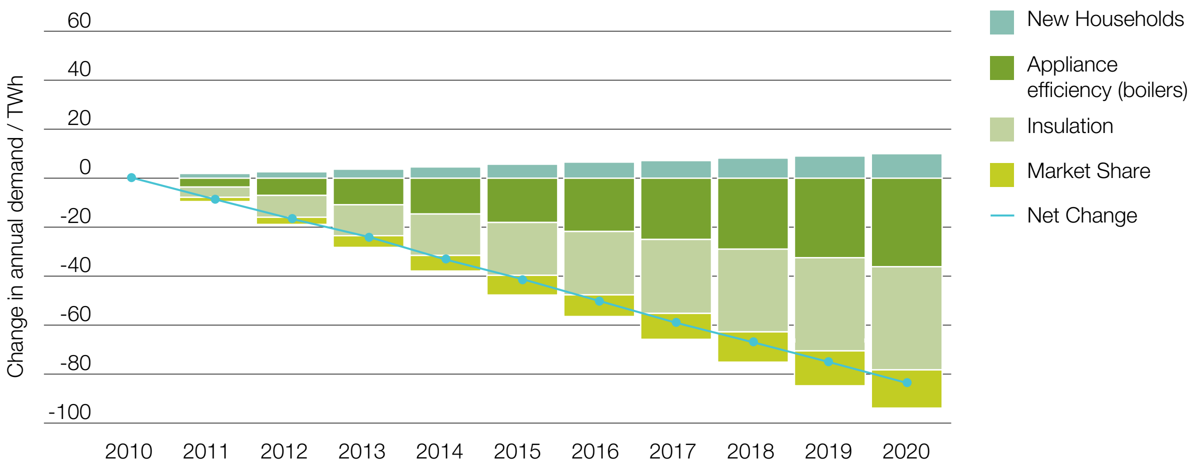
The average efficiency of gas boilers installed increases from 72% to 83% by 2030, driven by the replacement of boilers as they reach the end of their natural lives by high efficiency condensing boilers. Although new condensing boilers have a projected efficiency of over 90%, the continuing presence of older boilers in the existing housing stock means that the average efficiency does not approach this level over the next two decades.

Heat pumps are adopted from a very early stage by homes not connected to the gas network, where existing heating is principally oil fired or electric resistive heating (storage heaters or incandescent heaters).

Heat pumps are dominant in the new build market from 2015 as developers move towards the target for zero carbon homes. Smaller existing properties which require little work to insulate will also start to utilise heat pump heating systems after the market has been developed by these early movers. The retrofit market grows strongly from 2019. For larger properties which have higher peak heat loads there will be some hybrid heating systems in place allowing for a small heat pump providing base load heat with high efficiency gas boilers delivering peak heating requirements.

12 www.decc.gov.uk/assets/decc/11/stats/energy/energy-efficiency/2660-statistical-release-ests-home-insulation.pdf
13 www.communities.gov.uk/publications/planningandbuilding/zerocarbonia

Figure 9.
Changes in residential gas demand: Gone Green



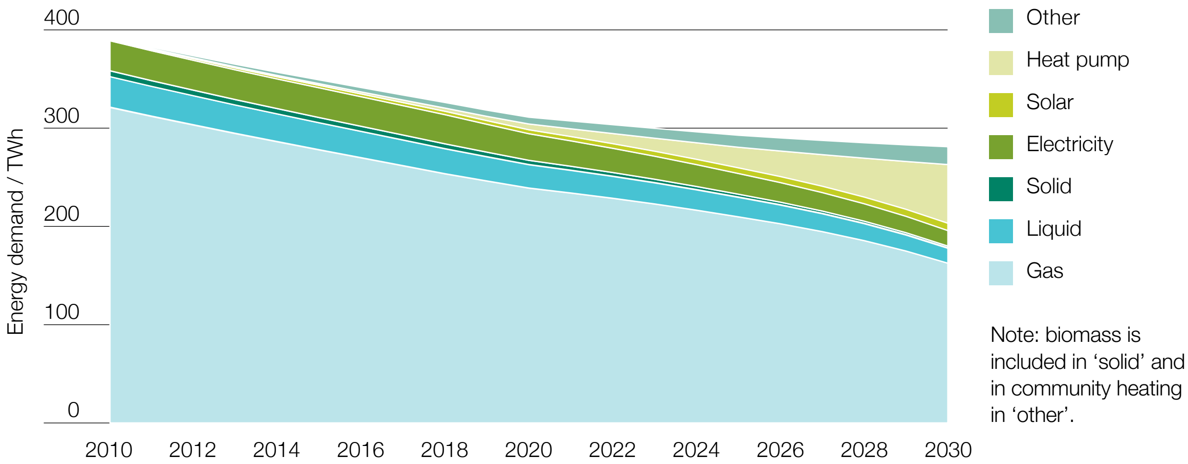
Gone Green has 1.2 million domestic heat pumps by 2020 and 7.7 million by 2030.

National Grid has carried out limited analysis of the solar thermal heating market, so in the absence of further information the total level of solar thermal is set to the value used in DECC pathways trajectory 2, giving 8 TWh in 2030, of which 95% is assumed to be in the residential market.

Micro CHP receives no support under the RHI and only limited support under the electricity feed-in-tariffs. Comparatively few units have been installed so far so the current Gone Green assumes no further roll out. This is consistent with the DECC pathway Alpha.

The cumulative effect on gas demand of these factors is shown in Figure 9. Note that, in contrast to Slow Progression, there is no increase due to the behavioural change or 'comfort factor', which is the tendency of consumers to respond to improved insulation with higher household temperatures rather than reduced energy demand. This is in line with DECC pathway Alpha which assumes only a 0.5 °C increase in internal temperatures by 2050.

Figure 10.
Energy use in residential heating: Gone Green



Note: biomass is included in 'solid' and in community heating in 'other'.

There is no detailed analysis of biomass use within the residential sector. Biomass for all heating use rises from 15 TWh in 2011 to 18 TWh in 2020 and 21 TWh in 2030. DECC have proposed that emission performance standards will be needed for biomass boilers as a condition for receiving RHI[14] payments, but this constraint has not been included in the Gone Green modelling.

Figure 10 shows the energy use by fuel type in the residential heating market in the Gone Green scenario.

Services and industry

Analysis of non-residential heating demand differs from the residential sector in that the number of properties is not used, but rather heat demand for the whole sector is considered. Reductions in heat demand are dependent on improvements in insulation but also on economic growth. After taking into account both the economic growth and the improved insulation, demand for heat in the services sector rises by 7% between 2011 and 2030.

In the industry sector the demand for heat is divided into low temperature heat (space heating of industrial buildings), which is suitable for application of heat pumps, and high temperature or process heat, where heat pumps cannot be used, but where there may be some scope for biomass boilers.

National Grid's detailed research on heat pumps concentrated on the residential sector, so for the non-residential sectors other data sources were needed. Values from a consultation on the renewable heat incentive by Nera for DECC[15], from the CCC 4th budget and from DECC 2050 pathway Alpha were all considered, as shown in Figure 11. For the industrial sector the forecast from CCC4 was used, whilst for the services sector a value based on CCC4 but adjusted for a lower total heat demand was used.

CHP

In Gone Green, CHP is modelled principally as a source of heat; the associated electricity generated is offset against the overall electricity demand. As is the case for Slow Progression,

14 www.decc.gov.uk/assets/decc/11/meeting-energy-demand/renewable-energy/2167-uk-renewable-energy-roadmap.pdf
15 http://www.decc.gov.uk/assets/decc/consultations/rhi/1_20100129161148_e_@@_designoftherenewableheatincentiveneraReport.pdf

the market for gas-fired CHP is not expected to grow significantly, but there will be growth in the biomass CHP market. Figure 12 shows the fuel use in CHP in the industrial and services market.

Gone Green Renewable heat

Renewable energy makes up 12% of the heat market in Gone Green in 2020, rising to 37% by 2030.

Figure 11.
Total heat provided by non-domestic heat pumps

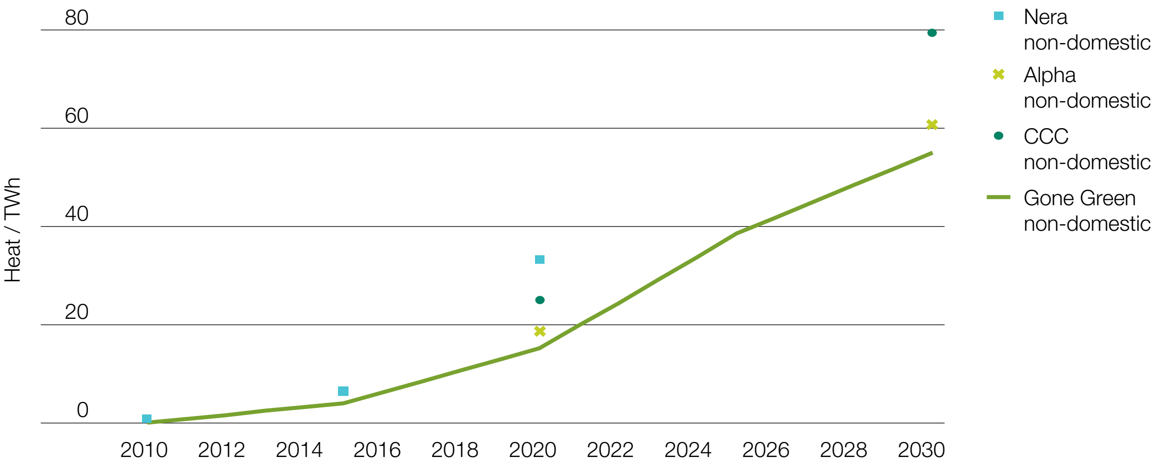
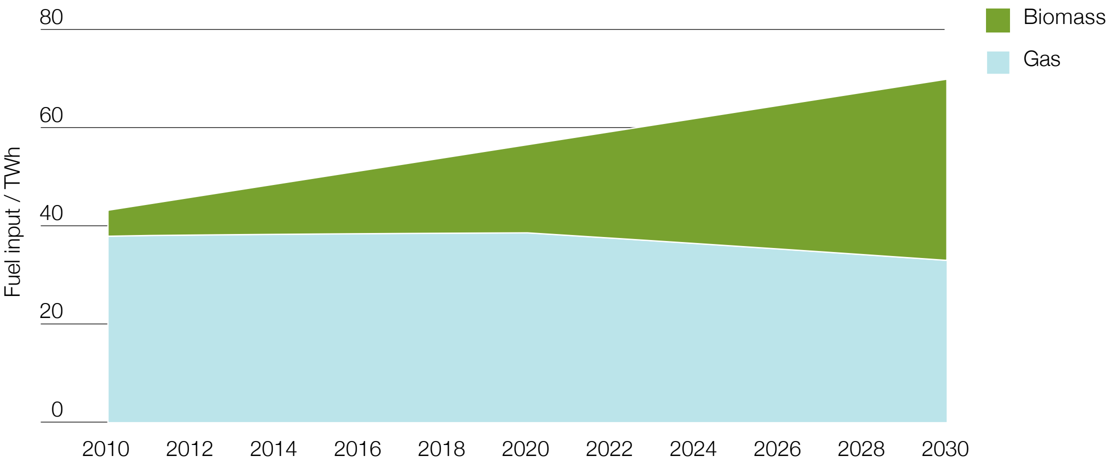


Figure 12. .
Fuel use in CHP: Services and Industrial excluding Refineries: Gone Green



2.4 Transport

2.4.1 Electric Vehicles

The successful introduction of electric vehicles (EVs) will be a key part of the move toward meeting environmental targets, so National Grid has modelled this area in some detail.

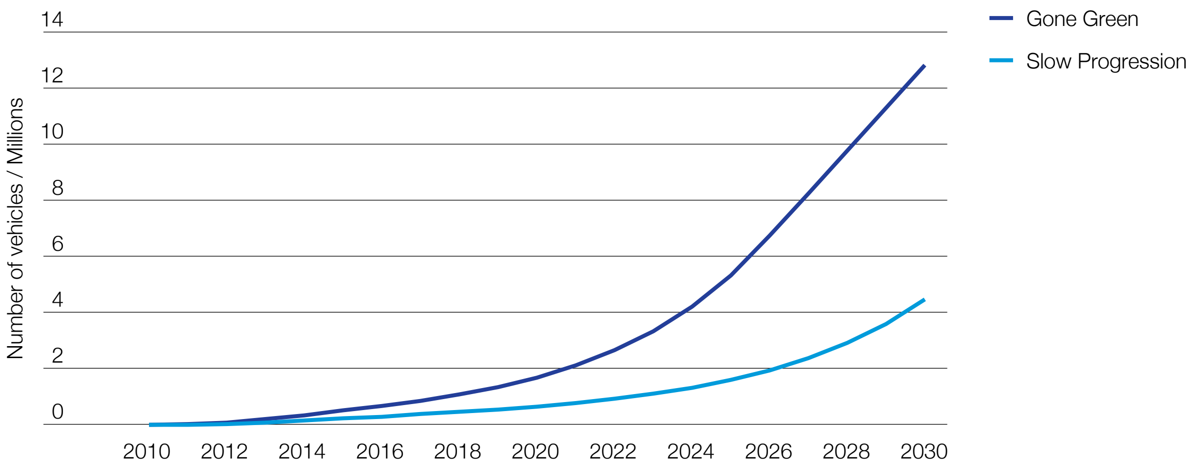
The method of analysis is similar for Gone Green and Slow Progression, differing mainly in the dates by which technology milestones are achieved. Data from manufacturers and industry bodies have been used, and projections have been benchmarked against forecasts from the Department for Transport (DfT) and the Office for Low Emission Vehicles (OLEV).

EVs first make significant progress in London, where they enjoy exemption from the congestion charge, and concessions in parking and charging. Hybrid vehicles, which use both electric and conventional internal combustion engine technology, and plug-in hybrids, which are similar but also have the capability to recharge their batteries from the mains rather than relying solely on the internal combustion engine for charging, are important in the early years of EV development.

The fleet market, for rental, leasing and company use, is also an early adopter. As prices of new vehicles fall and the range of models expands, there is some take-up in the domestic market for second cars, though the market for first cars is still dominated by conventional petrol or diesel vehicles. Once the problems, perceived or otherwise, of range per charge, charging duration and charging point availability have been solved, EVs become mainstream vehicles. Market saturation is assumed when 75% of new cars purchased each year are electric.

Figure 13 shows the forecast number of electric cars in Gone Green and Slow Progression.

Figure 13.
Number of electric cars



2.4.2
Slow Progression Transport

In Slow Progression the only part of the transport sector to be modelled explicitly is the electric vehicle market, described in general terms above.

The roll-out in London and the fleet market dominates in the years 2012 to 2015. The domestic market for second family cars develops up to 2020, with the market for first cars developing from 2023 after improvements in battery technology giving increased range. Hybrids and plug-in hybrids make up 27% of the total EV fleet in 2020, falling to 9% by 2030. By 2030 EVs make up 42% of the new car sales, giving a total of 4.5 million vehicles on the road.

2.4.3
Gone Green Transport

In Gone Green the requirement to account for all CO_2 emissions means that the transport sector has to be modelled in much more detail that in Slow Progression.

Total passenger land transport increases by15% by 2030 but, as the efficiency of internal combustion engines increases over the period, the total energy requirement decreases by around 40%, as shown in Figure 14.

There is some movement of passenger traffic from road to rail; rail makes up 7% of total passenger journeys in 2010 increasing to 9% in 2030.

The roll-out of EVs is concentrated in London and in the fleet market in the years to 2015 as in Slow Progression, though the number of vehicles sold is greater. Development in the market for second family cars is complete by 2017, three years earlier than in Slow Progression. Advances in battery technology allow EVs to enter the first car market from 2017. Hybrids and plug-in hybrids make up 10% of the total EV fleet in 2020, falling to 3% by 2030. Saturation of the market (75% of new car sales) is reached by 2027, with 12.8 million vehicles on the road by 2030.

Freight traffic increases by 1.5% per year to 2030. Rail makes up 12% of freight traffic in 2020, rising to 15% by 2030. There is an increase in HGV engine efficiency but, unlike the passenger sector, this is not sufficient to bring about a reduction in emissions from freight transport. There is limited use of Compressed Natural Gas (CNG) in hybrid powered HGVs by 2030 and no use of hydrogen powered vehicles before 2030.

Forecasts for energy use in shipping were taken from the 'Updated Energy Projections'[16] (UEPs), the most recent forecast available from DECC at the time. Forecasts for aviation were based on the 'likely' scenario from the CCC report 'Meeting the UK aviation target'[17].

For shipping, only national navigation is included here; international shipping is currently excluded from the carbon emissions budgets, though the CCC have recommended that international aviation and shipping (IAS) should be included in future budgets and that the first, second and third carbon budgets should be adjusted to include IAS.

16 www.decc.gov.uk/media/viewfile.ashx?filetype=4&filepath=Statistics/Projections/50-annex-c-final-energy-demand-.xlsx&minwidth=true
17 www.theccc.org.uk/reports/aviation-report

For aviation the emissions are excluded, but a portion of the energy demand, capped at 6.18%, is included in the calculation of the total renewable energy fraction, in line with the EU renewable energy legislation[18].

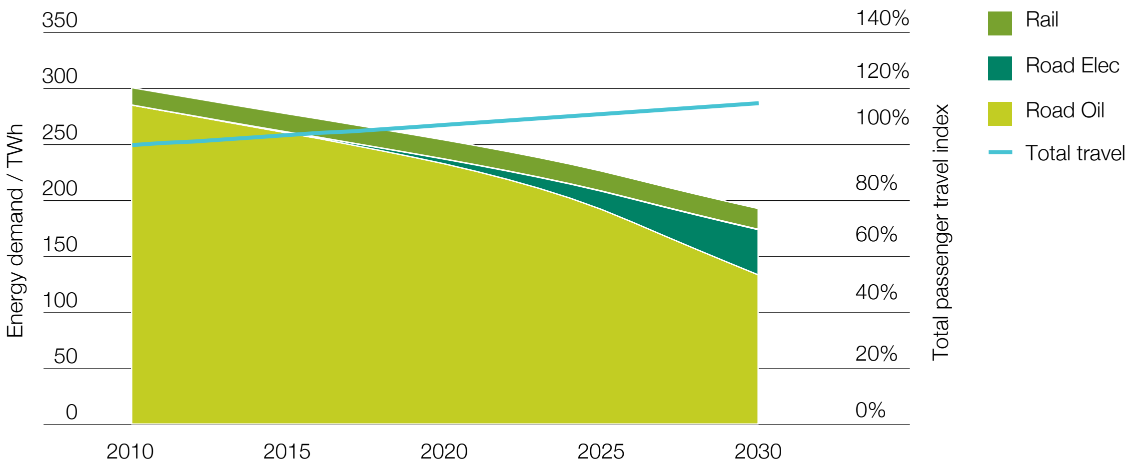
The use of biofuel in road transport increases to 8% by 2020 and then at a slower pace to 2030. Towards 2030, developments in 2nd and 3rd generation biofuel production mean that biofuel usage shifts towards the aviation market where viable alternatives to liquid fuel do not exist and there is a strong need to reduce increases in CO_2 emissions.

Gone Green renewable transport

Renewable energy makes up 7% of total transport in 2020, rising to 10% in 2030. Note that these values use the aviation capped emissions described above.

18 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF

Figure 14.
Energy demand for passenger land transport



2.5

Electricity demand

Great Britain is expected to be a net exporter of electricity to Northern Ireland via the existing Moyle interconnector and Ireland via the new East-West interconnector from 2012. Total exports from GB are expected to increase following the addition of the East-West interconnector, although some displacement of flows is assumed. Over the longer term, net exports from GB are predicted to gradually decline as Ireland develops more indigenous power generation, notably wind capacity.

Imports and exports

Assumptions on the capacity and utilisation capacity of interconnectors with Ireland and continental Europe are common to Gone Green and Slow Progression.

Electricity will flow in both directions between continental Europe and GB, but net exports to continental Europe are not expected to change from now to 2030. There is considerable uncertainty about future flows following the unbundling in the European third package, but these are captured in sensitivities around our scenarios.

It is assumed that at times of peak demand, electricity will always be flowing from GB to Ireland, but that the interconnectors between GB and continental Europe will be neither importing nor exporting at times of peak demand.

Heat pumps and transport have been discussed in previous sections. This section concentrates on the remaining elements of the electricity demand projections.

2.5.1
Slow Progression Electricity

Annual electricity transmitted through National Grid's network is derived from a number of key drivers:

- Historic annual electricity consumption;
- Economic background, including fuel price. See section 2.2;
- New emerging technology such as heat pumps and electric vehicles. See sections 2.3.1 and 2.4.2;
- Embedded generation (generation connected to a distribution network rather than to the transmission network);
- Energy efficiency measures.

Embedded Generation

Embedded generation is generation directly connected to an electricity distribution network rather than the transmission system. In England and Wales embedded generation is less than 100 MW in capacity while in Scotland the size of embedded generation varies from less than 30 MW in the area covered by Scottish Power Transmission Ltd (SPTL) and less than 10 MW in the area covered by Scottish Hydro Electric Transmission Ltd (SHETL).

Embedded generation is made up mostly of CHP, wind, biomass or other renewable generation. CHP makes up the largest part of this and output is expected to rise from the current level of around 20 TWh to 31 TWh by 2030.

Embedded wind capacity is expected to rise from the current level of 2.1 GW to 3.1 GW by 2030, with output rising from 5.4 TWh to 7.8 TWh over the same period.

Little change is expected in embedded hydro generation, with output just below 2 TWh.

Micro-generation, comprising domestic solar PV, hydro and wind, makes very little contribution in Slow Progression, remaining below 1 TWh in 2030.

Energy efficiency

Energy efficiency measures include savings from energy saving light bulbs, appliances and insulation.

The UK has a target to phase out the production of all incandescent bulbs by 2012 with the aim of encouraging the use of energy efficient alternatives such as compact fluorescent light bulbs (CFLs) and LED lamps. Energy efficient lighting accounts for half of the total energy efficiency savings based on the assumption that there are 25 – 30 million CFLs being replaced per year up to 2020.

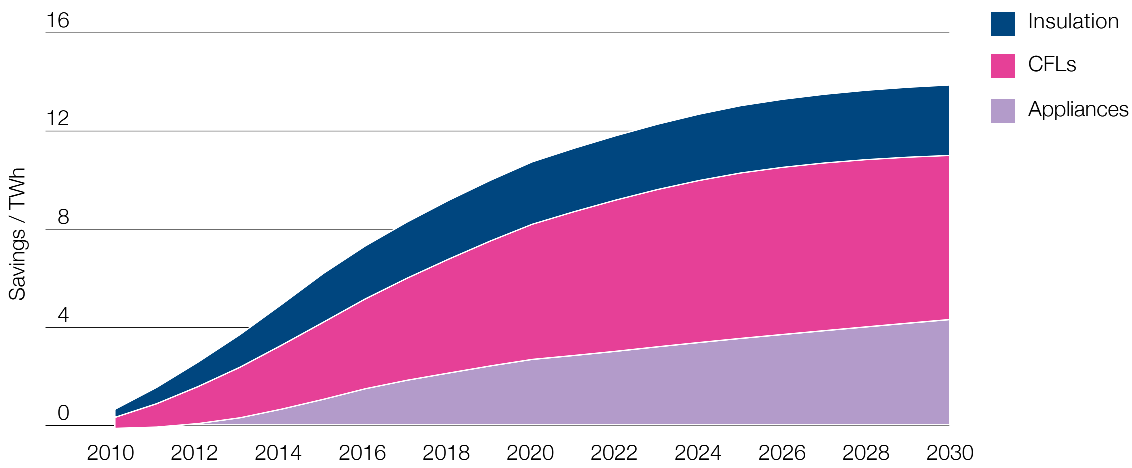
Appliances contribute one quarter of the all efficiency savings up to 2020. This includes replacing old/current appliances with new appliances such as 'white goods' (fridges, freezers, washing machines and dishwashers), cooking appliances (electric ovens and microwaves) and electronics (TVs and computers).

The remaining savings come from loft, cavity wall and solid wall insulation. Cavity wall insulation accounts for two thirds of insulation savings up to 2020 but reduces down to about one half by 2030.

Total energy efficiency savings are 11.3 TWh by 2020 and 14 TWh by 2030 as shown in Figure 15.

2.5 continued
Electricity demand

Figure 15.
Efficiency savings in the electricity market: Slow Progression



Smart Meters

The introduction of Smart Meters when coupled with time of use tariffs is intended to provide demand side management at times of peak demand. It is assumed that the majority of domestic customers will have Smart Meters installed by 2020, reaching 100% installation by 2025. Utilisation of the technology increases as customers become more familiar with it and aware of the advantages, and this leads to reductions in annual energy and peak demand as shown in Figure 16. Note that the annual demand line flattens in the early 2020s, whilst the peak reduction keeps rising. The effect on annual energy consumption is less than on peak as in many cases demand is moved from peak time to off-peak time rather than lost altogether.

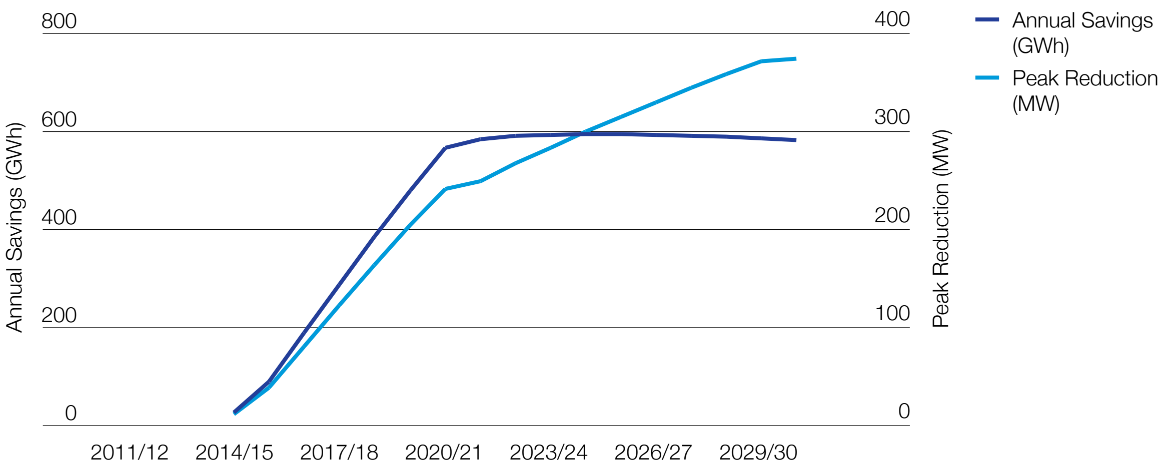
Annual energy

Comparing annual electricity demand between Slow Progression and Gone Green is not straightforward:

- Slow Progression modelling is at GB level whilst Gone Green is modelled for the whole of the UK, including Northern Ireland
- CHP is treated differently in the two scenarios
- Imports, exports, embedded generation, pumped storage pumping demand and power stations' own use are also treated slightly differently.

Nevertheless, a useful comparison can be made by considering the requirement for transmission connected generation, once adjustments for all the factors listed above have been made. The comparison is shown in Figure 20.

Figure 16.
The effect of Smart Meters on annual and peak demand: Slow Progression



Peak demand

Peak demand[19] is derived from estimates of annual demand. In the first few years of the scenario period the relationship between peak and annual, expressed in the Load Factor is assumed to follow the pattern of historical values. Later in the scenario period the load factor is changed to reflect the effect of new technologies:

- It is assumed that most electric vehicles will charge in off-peak periods, but a small number will be charging at peak (typically 5:30 – 6:00 pm, when many commuters will be returning from work. This will increase the peak demand;
- Heat pumps will displace electric resistive heating. Although the annual electricity demand resulting from this change will increase, heat pumps have a flatter demand profile, and in many cases the peak heat load will be met by gas rather than the heat pump, as described in section 2.3.1. The net effect of this is a decrease in peak demand;
- Smart meters and time of use tariffs will displace demand from the peak to off-peak periods.

Peak demand for Slow Progression and Gone Green is shown in Figure 21

19 Peak demand discussed here is always the Average Cold Spell (ACS) peak demand on the GB transmission system, excluding exports and power stations' own demand

2.5.2
Gone Green Electricity

Gone Green has projections for annual electricity demand and derived peaks for the whole UK. The main drivers are the same as in Slow Progression, and of these, the economic background, heating and electric vehicles have already been discussed.

Embedded generation

There is more renewable embedded generation in Gone Green than in Slow Progression, especially in the biomass, onshore wind and tidal and wave categories, as shown in Figure 17. Gone Green has a total embedded generation (excluding CHP) of 37 TWh, compared with 24 TWh in Slow Progression

Micro Generation develops more strongly in Gone Green than in Slow Progression. Generation from Solar PV and micro wind is taken from DECC pathway Alpha and is shown in Figure 18 along with the total microgeneration from Slow Progression. Gone Green PV reaches 0.9 GW of installed capacity in 2020 and 5.8 GW in 2030, whilst micro wind reaches 0.6 GW in 2020 and then rises no further.

Energy efficiency

Energy efficiency gains in Gone Green are more ambitious than in Slow Progression. The majority of incandescent bulbs are replaced and all cold and wet appliances (fridges, freezers, washing machines etc) are replaced with appliances with the highest efficiency rating.

Figure 17
Embedded renewable capacity: Slow Progression and Gone Green

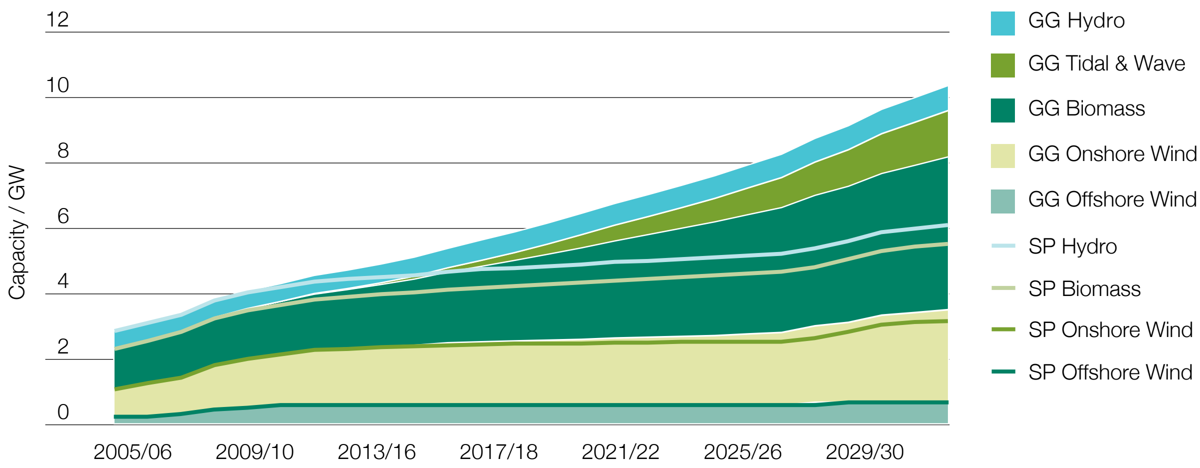


Figure 18
Microgeneration in Gone Green and slow Progression

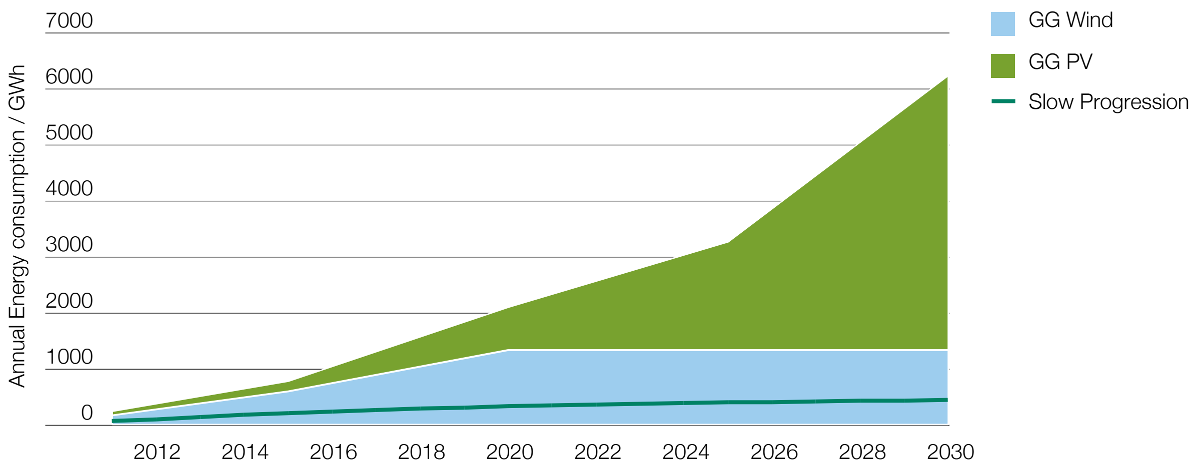


Figure 19.
Residential electricity demand: Gone Green and Slow Progression

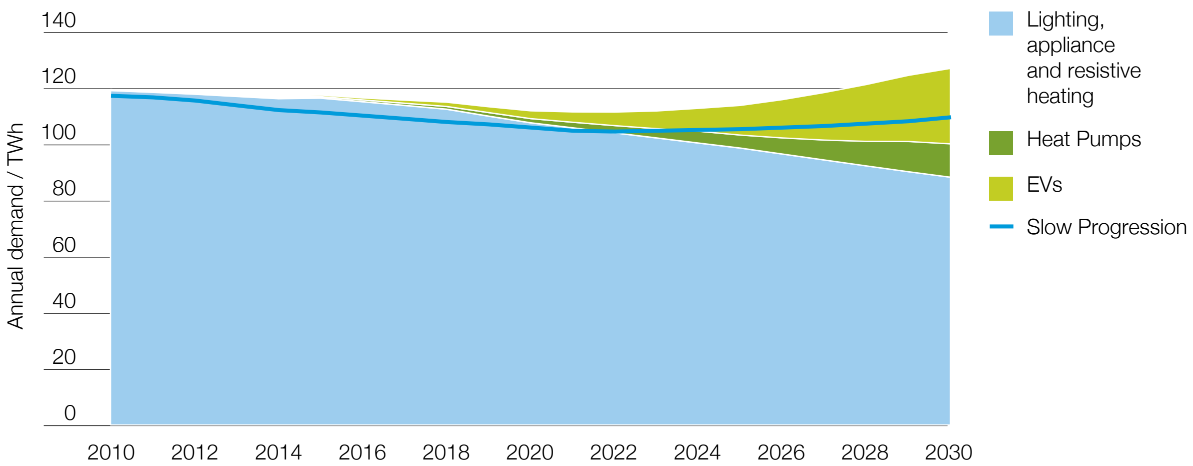


Figure 19 shows residential electricity demand by end use, with Slow Progression for comparison.

Annual Energy

As has already been mentioned, comparison of annual energy between Gone Green and Slow Progression is not straightforward, due to different treatment of a number of factors in the two scenarios. Nevertheless a useful comparison can be made of the requirement of Transmission connected generation, as shown in Figure 20.

Peak Demand

As is the case for Slow Progression, in the first years of the scenario the load factor relating peak demand to annual demand is in line with historical patterns. In later years the load factor is adjusted to reflect the effect of new technologies, heat pumps, electric vehicles and smart metering and time of use tariffs, in a similar fashion to Slow Progression. However, the greater penetration of heat pumps and smart meters in Gone Green leads to a greater reduction in peak demand which is not offset by the increase in electric vehicles.

Peak demand for Slow Progression and Gone Green is shown in Figure 21.

As is the case for Slow Progression, in the first years of the scenario the load factor relating peak demand to annual demand is in line with historical patterns.

Figure 20.
Requirement for generation: Slow Progression and Gone Green

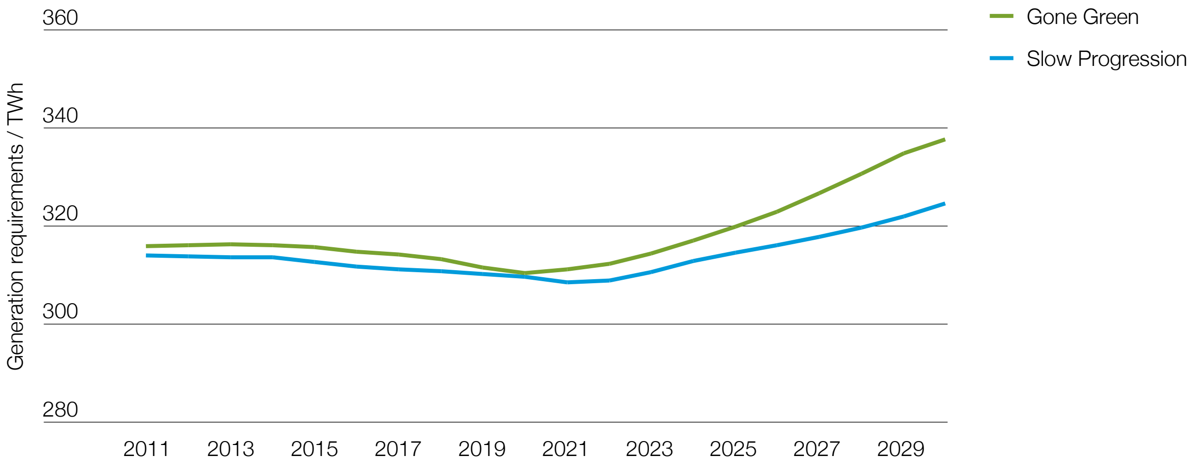
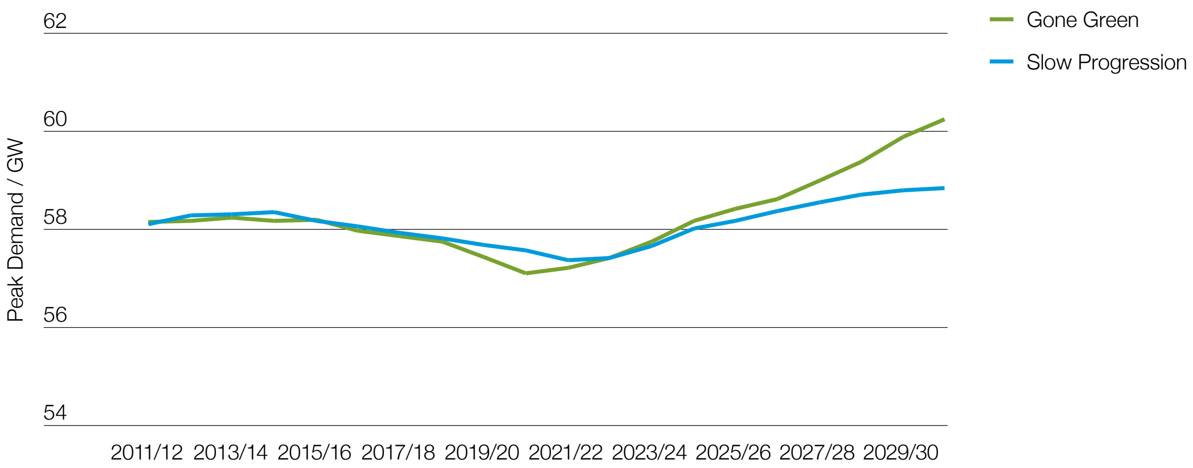


Figure 21
ACS peak demand: Slow Progression and Gone Green



2.6 Electricity Generation

Each scenario has a mix of generating capacity that is adequate to meet the forecast of ACS peak demand, shown in Figure 21. Remember that Accelerated Growth uses the same energy demand as Gone Green. A plant margin of around 20% is achieved in each scenario, and assumes no imports from Europe and a contribution of 5% from wind generation. As an additional constraint, a plant margin of around 10% is calculated using Equivalent Derated Capacities[20], in which not only is the contribution from wind reduced to 5% of capacity, but the contribution from conventional plant is also reduce from nameplate capacity to reflect likely availability.

20 EDC – Equivalent Derated Capacity. Concept explained in Winter Outlook Report 2010/11 Consultation www.nationalgrid.com/uk/Gas/TYS/outlook

A number of assumptions are common to all scenarios

- LCPD – The impact of the Large Combustion Plant Directive (LCPD) and the predicted closure dates of stations that have opted out of the LCPD are consistent in all scenarios;
- Magnox Closures – The two Magnox nuclear plants close at the same time in each scenario
- AGR life extensions – The AGR nuclear plants are assumed to receive life extensions in all scenarios. These are set at five years from the original planned closure dates (unless otherwise announced), apart from in the Gone Green scenario where an additional five years is assumed;
- Interconnectors – In all scenarios, continental interconnectors are assumed to operate at 'float' when calculating the plant margin. The interconnectors to Ireland are assumed to be exporting at the time of system peak. Interconnector capacity assumptions are consistent across all scenarios: capacity rises to 7.6 GW by 2020;
- For security of supply purposes, wind is assumed to contribute little at the time of system peak demand. The 5% contribution is based on experience in the previous two winters when high demands combined with low output from wind generation.

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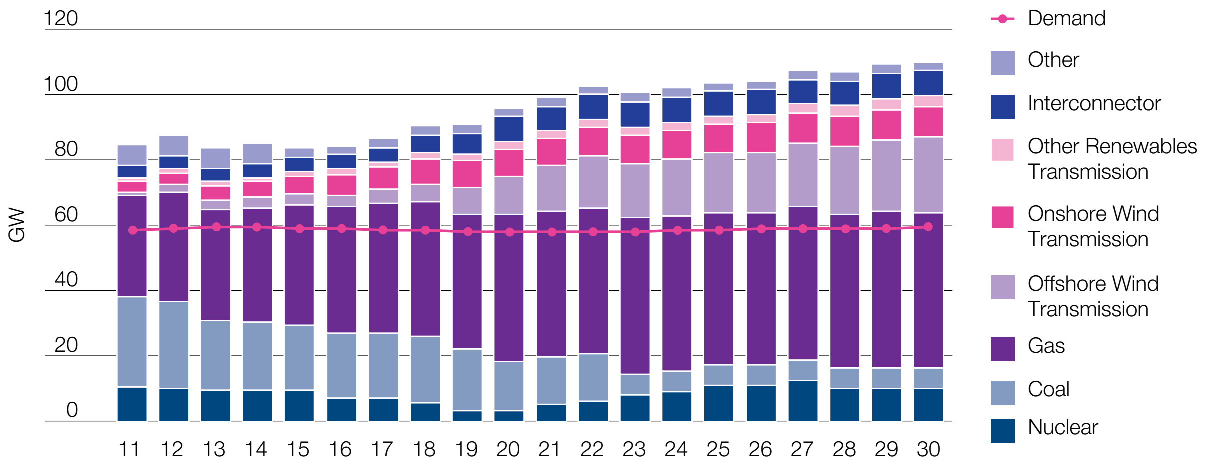
2.6.1
Slow Progression

In Slow Progression there is a slower build up of lower carbon generation and a greater reliance on gas-fired plant. The scenario also assumes slower advances with regard to new technology, with carbon capture and storage (CCS) proving to be uneconomical for large scale coal plants.

Summary:
- AGR nuclear plant receives five-year life extensions unless otherwise announced;
- First new nuclear plant connects in 2021/22, with a slower build up of new nuclear capacity than in the other two scenarios;
- The majority of existing coal plant closes by 2023 due to a combination of the IED and the age of the plant;
- No new coal plant is built apart from the government funded pilot project with CCS coal plant assumed to prove uneconomic;
- Existing gas-fired plant remains open for longer than in the Gone Green scenario;
- A significant amount of new gas-fired generation is constructed in the period between 2015 and 2023 in order to maintain the required level of capacity. A total of 21GW of new conventional CCGT plant is included in the scenario by 2030;
- 6 GW of new gas plant with CCS is included in the forecast from 2023;
- The build up of wind generation is lower in this scenario with 20 GW of wind capacity in 2020 (11 GW offshore) and 32 GW (23 GW offshore) in 2030;
- Marine generation is assumed to develop very slowly with larger scale generation not connecting until around 2027.

The Slow Progression demand and associated generation background are shown in Figure 22.

Figure 22.
Demand and Generation Background: Slow Progression



2.6.2
Gone Green

This scenario includes a more rapid build up of wind generation, with the supply chain, and thus growth in offshore wind, maintained post 2020. Nuclear AGR plant is assumed to receive an additional five years life extension when compared with the Slow Progression scenario, maintaining the level of nuclear capacity until the advent of new nuclear plant, and assisting in lowering the level of carbon emissions from the generation sector. CCS plant is envisaged at both coal and gas plants into the future, with thermal plant developed after 2023 required to have CCS technology. The increased lifespan of the AGR plant results in existing CCGT plant closing earlier than in the other scenarios.

Summary:

- AGR nuclear plant receives additional five-year life extensions beyond the closure dates in Slow Progression;
- First new nuclear plant connects in 2019/20;
- The majority of existing coal plant closes by 2023 due to a combination of the IED and the age of the plant;
- 4 GW of coal with CCS connects post 2023 in addition to the government funded pilot project;
- Existing gas-fired plant is assumed to close at around 25 years of age;
- A total of 13GW of new conventional CCGT capacity connects over the period;
- 7 GW of new gas plant with CCS is included in the scenario from 2023;
- The build up of wind generation reaches 26 GW of wind capacity in 2020 (17 GW offshore) and 47 GW (37 GW offshore) in 2030;
- Marine generation develops more quickly than in the Slow Progression scenario reaching 4GW in 2030.

The Gone Green demand and generation background are shown in Figure 23.

Figure 24 shows generation further aggregated by fuel type. Also shown on this chart is the carbon intensity of generation, falling from around 500 g CO_2/kWh at present to 222 g CO_2/kWh in 2020 and 48 g CO_2/kWh in 2030.

Figure 23.
Demand and Generation Background: Gone Green

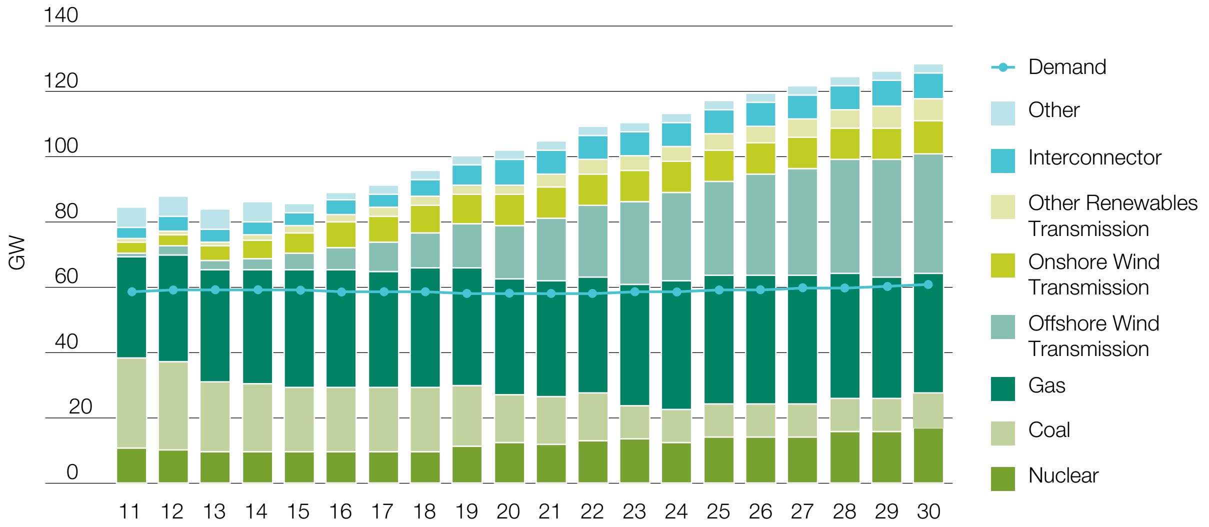
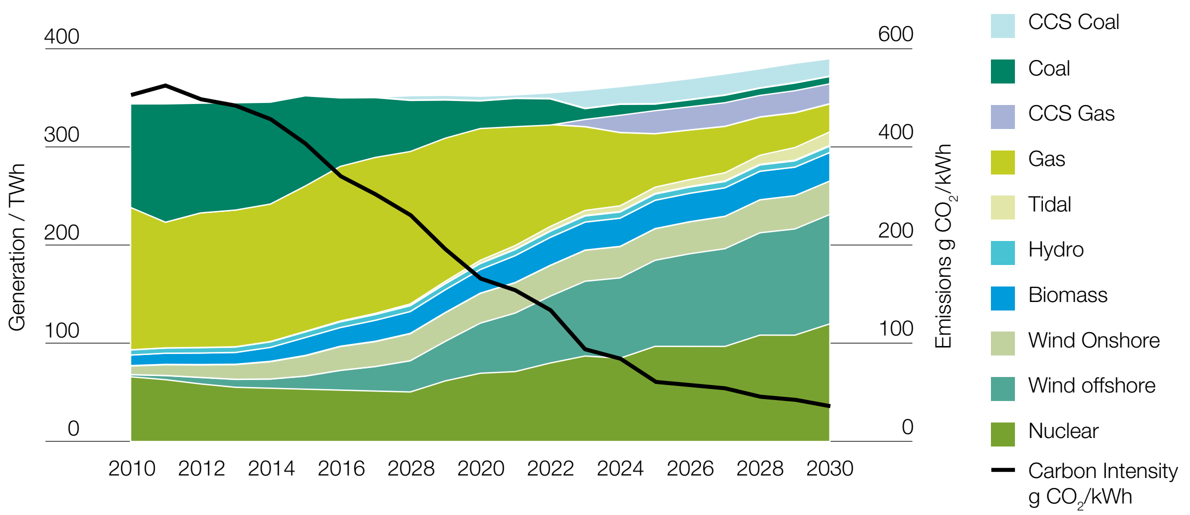


Figure 24.
Generation by fuel type and carbon intensity: Gone Green



2.6.3
Accelerated Growth

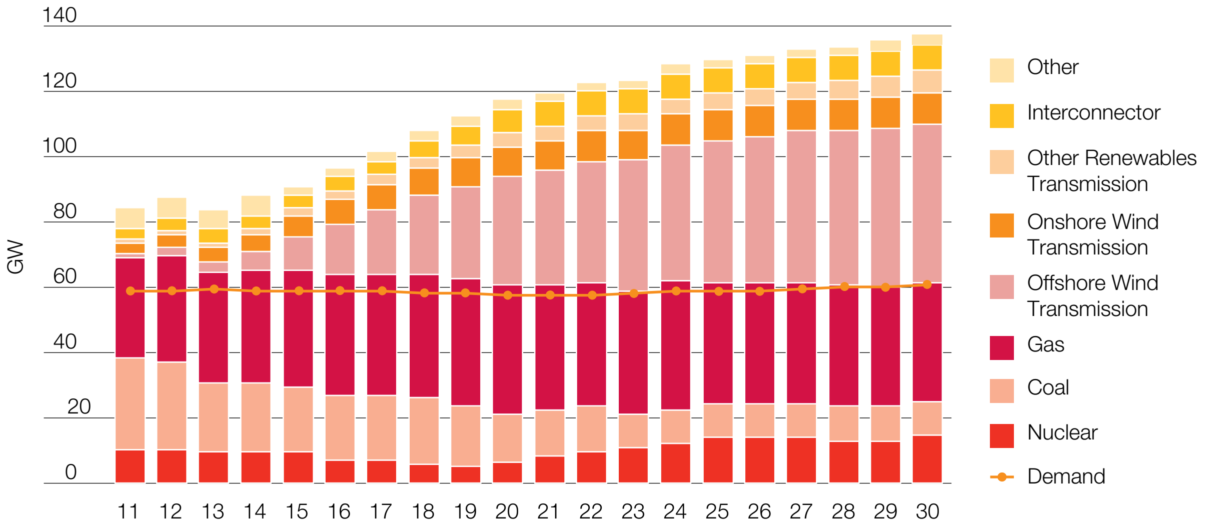
The Accelerated Growth scenario uses the Gone Green onshore background as a base with the assumption that offshore generation builds up far more quickly due to a rapidly established supply chain, higher carbon prices and strong government stimulus. The key differences in the onshore background are that the AGR plant is consistent with the Slow Progression scenario (AGR nuclear plant receive five-year life extensions unless otherwise announced) and that existing gas plant remains open for longer to maintain the plant margin and act as a back-up for the significant amount of wind generation.

Summary:

- AGR nuclear plant receives five-year life extensions unless otherwise announced;
- First new nuclear plant connects in 2019/20;
- Significant amount of new coal plant closes due to IED and age;
- 4 GW of coal with CCS connects post 2023 in addition to the government funded pilot project;
- Existing gas-fired plant remains open for longer as a back-up for the significant amount of wind capacity;
- A total of 13GW of new conventional CCGT capacity connects over the period;
- 5 GW of new gas plant with CCS is included in the forecast from 2023;
- The build up of wind generation reaches 42 GW of wind capacity in 2020 (33 GW offshore) and 59 GW (49 GW offshore) in 2030;
- Marine generation develops at a slightly quicker rate than in the Gone Green scenario albeit reaching around the same level in 2030.

The Accelerated Growth demand and generation background are shown in Figure 25.

Figure 25.
Demand and Generation Background: Accelerated Growth



2.7 Gas Demand

Gas demand is driven mainly by demand for heat and for electricity generation, both of which have already been discussed.

Some gas is used for non-energy purposes, for example as a feedstock in the manufacture of fertiliser. This is mostly at NTS industrial sites which are modelled individually in Slow Progression. Gone Green does not consider individual sites so the non energy use is based on values published in DUKES.

Gas exported to Ireland and continental Europe is important for network operation purposes, though it does not contribute to UK renewable energy or carbon emissions targets.

The forecast level of gas exports to Ireland is heavily influenced by the development of indigenous Irish gas supplies via the Corrib gas field. Exports to Ireland are expected to fall in the medium term due to the onset of these new supplies, although this project has suffered delays. Our current estimate is for gas to be supplied from Corrib from Q1 2013. Exports are then predicted to increase as these indigenous volumes decline over time. Flows to Ireland are the same in Gone Green and Slow Progression.

Gas can flow in both directions between UK and continental through the Interconnector (IUK) as described in section 2.8. IUK exports are higher in Gone Green than in Slow Progression as the UK demand for gas is lower.

Peak gas demand is based on a historical relationship between daily demand and weather[21] combined with the amount of gas fired electricity generating capacity. In contrast to the electricity market, where the peak demand is expected to fall relative to the annual demand over time, the trend in gas peak demand is harder to predict. Consequently the relationship between peak and annual demand is unchanged over time in both Slow Progression and Gone Green.

21 For details see http://www.nationalgrid.com/uk/Gas/OperationalInfo/operationaldocuments/Gas+Demand+and+Supply+Forecasting+Methodology/

Gas exported to Ireland and continental Europe is important for network operation purposes, though it does not contribute to UK renewable energy or carbon emissions targets.

Comparing gas demand across scenarios is not straightforward:

- Slow Progression gas demand is aggregated at NTS, export, and GB Distribution Network level, with limited information on market sectors;
- Gone Green gas demand is for UK, aggregated at market sector level regardless of the supply type.

However, it is possible to aggregate gas demands into broader categories in the two scenarios so that equivalent flows can be compared. In this aggregation 'Exports' includes flows from GB to the island of Ireland, with no distinction between Northern Ireland and Eire. Remember, Accelerated Growth uses the same energy demand as Gone Green. Figure 26 shows annual gas demand for Slow Progression (the filled areas) and Gone Green (the overlying lines), and Figure 27 shows the peak demand.

In Slow Progression:

- Insulation and efficiency saving in the residential and small I&C sectors is very nearly offset by the increase in number of houses, leaving demand very nearly flat to 2030;
- Demand in the large non-power sector is also fairly flat. There is comparatively little scope for energy saving in this sector, especially as there are few options for replacing gas in the high temperature heat market;
- Power generation demand remains fairly flat to 2020 with new gas-fired power generation capacity offsetting any increases in renewable generation. Post 2020, new nuclear capacity and increasing renewable capacity starts to erode gas share of the power generation market.

In Gone Green:

- Demand in the residential and small I&C falls steadily to 2030, reflecting more aggressive assumptions on insulation, boiler efficiency and the roll-out of heat pumps;
- The large non-power demand displays similar performance to Slow Progression, reinforcing the view that there are fewer opportunities for savings in this sector;
- In the short term, gas demand in the power generation sector remains stable as new gas capacity is commissioned. Demand falls steadily from around 2018 onwards in response to substantial offshore wind development and the first new nuclear station in 2019, with the trend continuing out to 2030.

Figure 26.
Annual gas demand in GB: Gone Green and Slow Progression

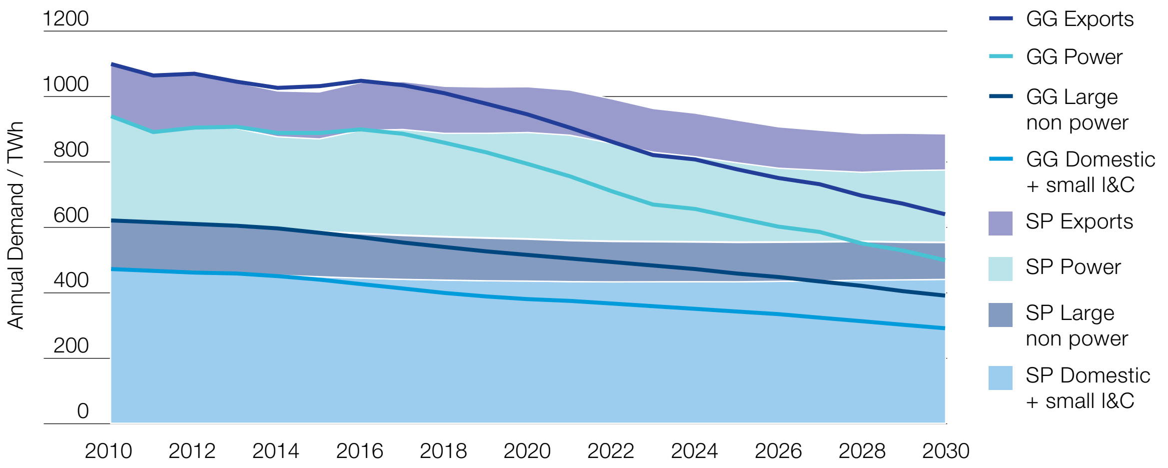
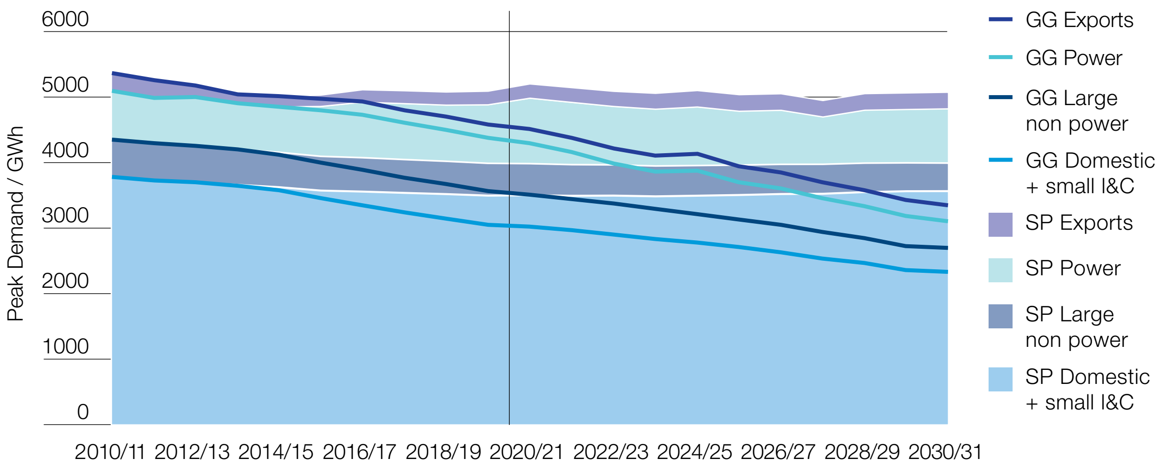


Figure 27.
Peak gas demand in GB: Gone Green and Slow Progression



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2.8
Gas Supply

In contrast to the energy demand scenarios, gas supply scenarios have not been specifically created to avoid multiple supply / demand combinations. Supply forecasts are based primarily on the resulting import requirement arising from the supply shortfall between annual demand and UK Continental Shelf (UKCS) supplies.

The UKCS forecast, shown in Figure 28, is based primarily on data from Oil and Gas UK gathered as part of National Grid's Transporting Britain's Energy (TBE) consultation, and reflects the aggregate view of UKCS upstream parties. This forecast was made prior to the government's announcement on tax changes. Changes arising from this are not expected to materially change the supply forecast. The UKCS forecast is essentially the same for Gone Green and Slow Progression.

The rate of UKCS decline is forecast to slow over the next few years due to the development of some medium sized fields, West of Shetland (post 2014/15) and a change in operating regime at Sean. The big drop between 2009/10 and 2010/11 is due to some offshore issues particularly at St Fergus and the cessation of Rhum due to EU sanctions against Iran (Rhum is jointly owned by BP and the Iranian Oil Company).

Though not shown, the supply forecasts include a contribution from unconventional gas, specifically coal bed methane (CBM) and biogas. The forecasts for unconventional gas are subject to considerable uncertainty. Shale gas is currently excluded from the forecasts, which therefore represent an upside.

The resulting import requirement can be sourced from Norway, the Continent or LNG. Due to proximity and limited export options, imports from Norway are considered first.

The Norwegian forecast, shown in Figure 29, is based on reported total reserves for the Norwegian Continental Shelf (NCS) and external forecasts for Troll and Ormen Lange. A UK forecast for Norwegian flows is based on the difference between Norwegian production and Norwegian exports to the Continent. Due to long term supply contracts and exports close to pipeline capacity, Continental exports are assumed to be relatively stable. Therefore the proportion of Norwegian gas to the broadly UK reflects the profile for total Norwegian production. This increases a little and then plateaus, before a gradual decline is forecast post 2015. As with the UKCS, the Norwegian forecast is essentially the same for Gone Green and Slow Progression.

Figure 28.
UKCS forecast

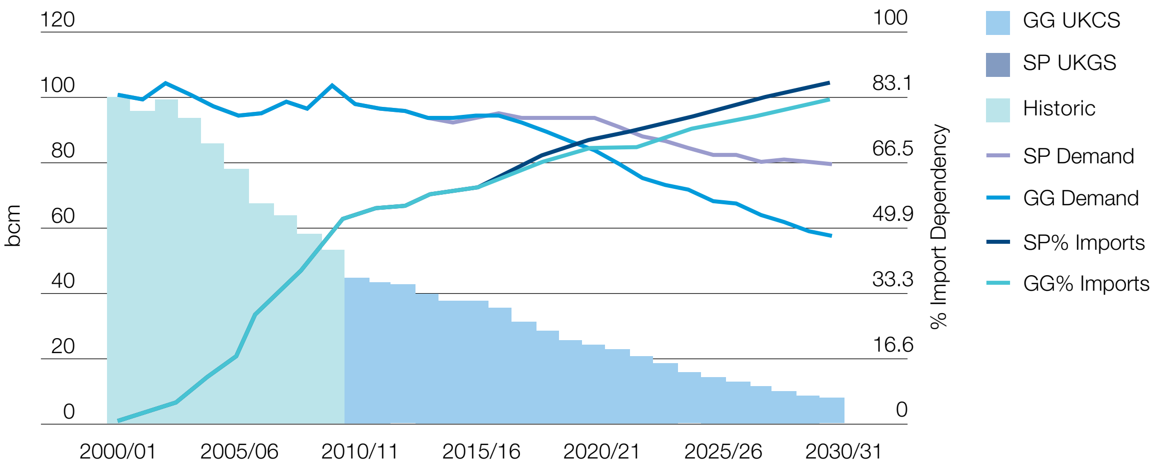
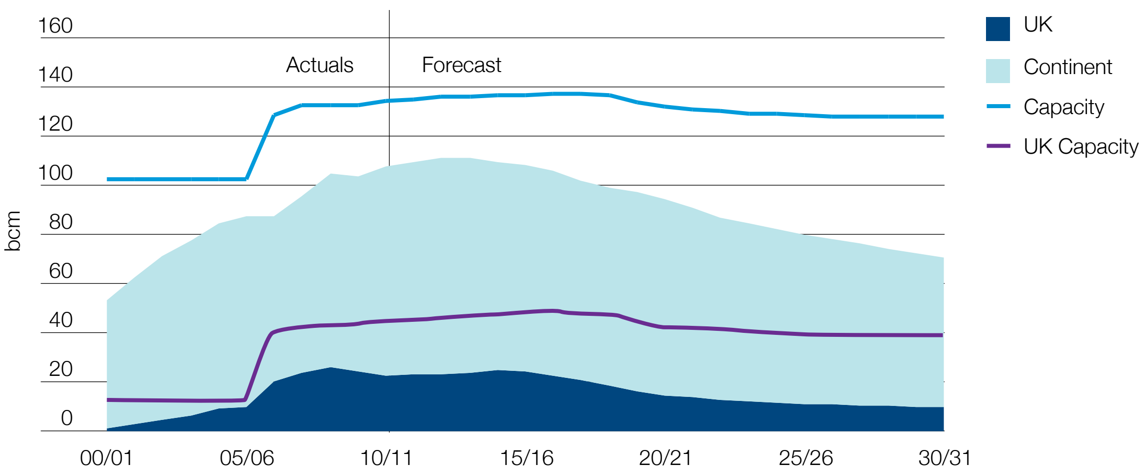


Figure 29.
Norwegian gas supply forecast



Gas Supply

With similar UKCS and Norwegian production profiles for the two demand scenarios, the resulting supply shortfall needs to be met by imports from LNG or the Continent. Due to higher demands, there is an increased import requirement in Slow Progression.

Due to recent history, supply availability and a view that LNG pricing will be competitive, there is a bias in the forecasts towards LNG rather than the Continent. For Slow Progression in particular, the resulting import requirement implies that further import capacity may be needed. To avoid 'picking winners', no new import or storage projects are included in the supply forecasts. For network planning, the impact of numerous new import and storage projects are assessed to determine potential network reinforcements and network investment. Though not detailed, alternative supply forecasts are also assessed, for example, high Continental imports and low LNG imports.

The LNG forecast builds on the surge in LNG imports since 2008/9. Due to the global nature of LNG and the options to flow to alternative markets and the view that much of the LNG to the UK is not specifically contracted, these forecasts are subject to high levels of uncertainty.

The LNG forecast is essentially the same for Gone Green and Slow Progression through to about 2017/18. The forecast includes a contribution from Teesside GasPort but no additional LNG expansion though high utilisation suggests additional LNG capacity could be needed.

The increase in LNG imports post 2015 is brought about through decline in UKCS and forecast commencement of decline from Norway.

LNG imports are higher in Slow Progression due to higher demand. LNG imports are shown to plateau at about 40 bcm or 70% of capacity. At these utilisation rates additional LNG import capacity may be needed; if it is not built some of the current LNG supply flexibility may be reduced.

The forecast for Continental flows includes imports through BBL and Interconnector (IUK) and exports through IUK. These imports / exports build on historic flows and on an annual basis only utilise some of the available capacity. For peak conditions most / all of the capacity is anticipated to be utilised. Due to supply options, like LNG, these forecasts are subject to considerable uncertainty.

The Continental forecast is essentially the same for Gone Green and Slow Progression through to about 2017/18.

The increase in Continental imports post 2015 in Slow Progression is brought about through a greater need for increased imports, which is caused by the decline in UKCS, forecast commencement of decline from Norway and high utilisation of existing LNG capacity. In Gone Green post 2015, imports are lower due to lower UK demand and exports are higher due to UK supply availability brought about by LNG imports.

Figure 30.
LNG forecast

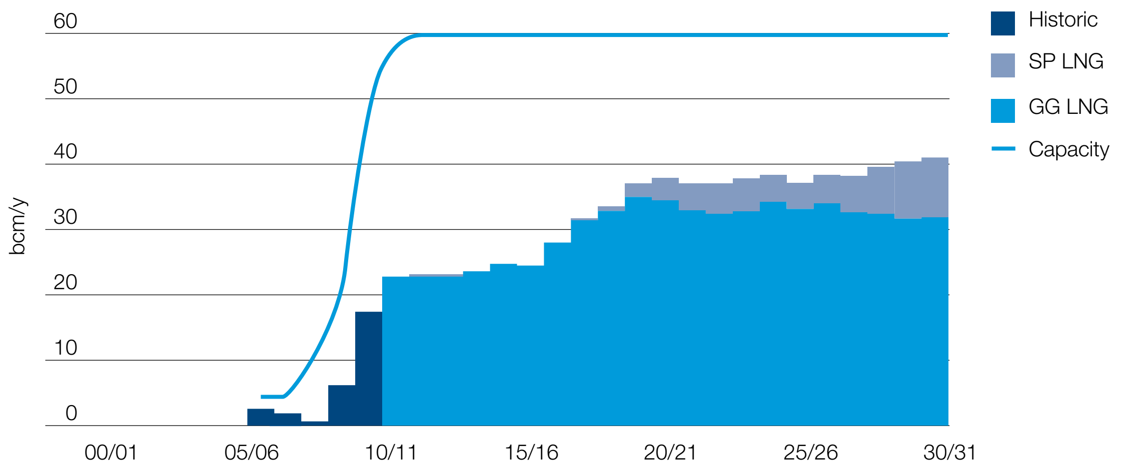
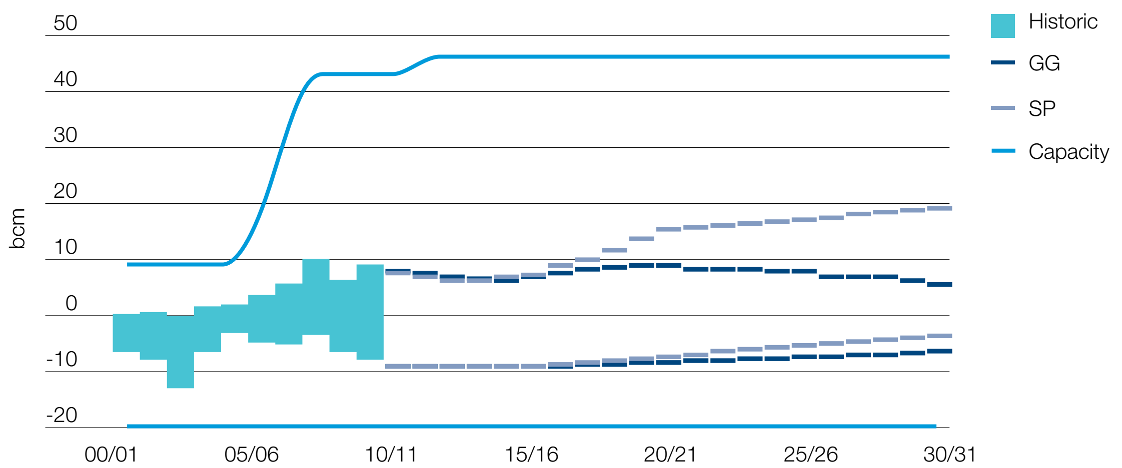


Figure 31.
Forecast gas supply from Continental Europe



Gas Supply

Figure 32.
Annual gas supply forecast: Gone Green

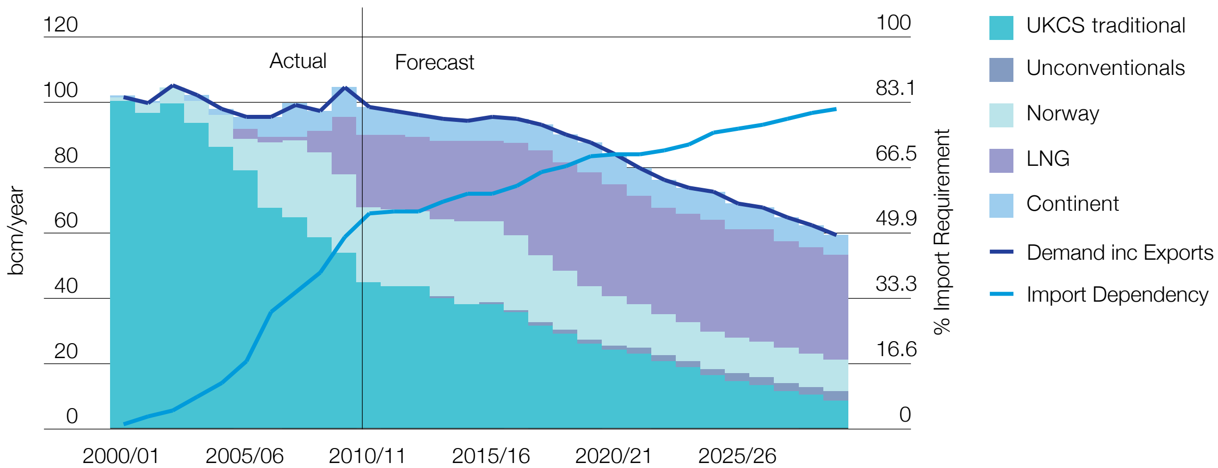
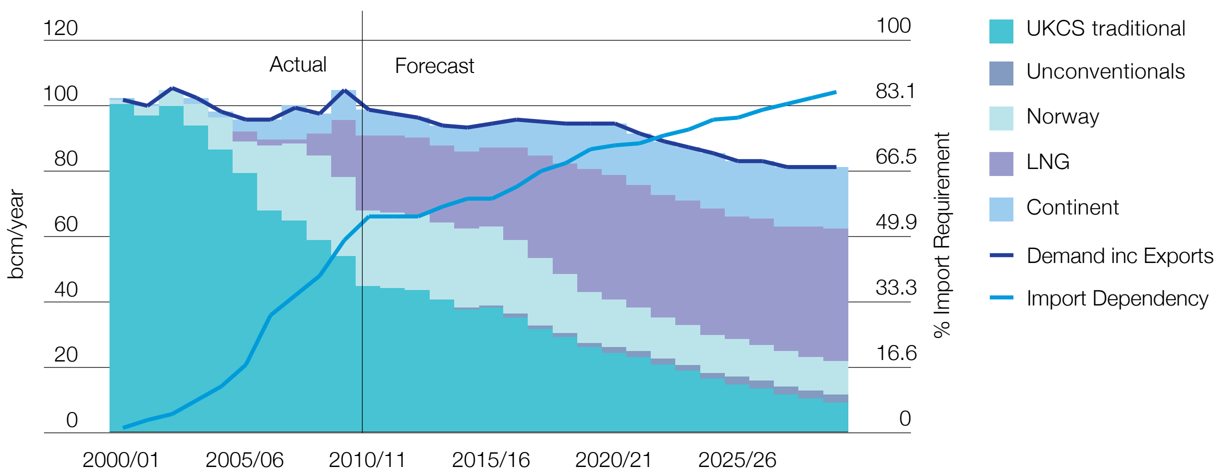


Figure 33.
Annual supply forecast: Slow Progression



The charts show similar levels of UKCS and imports from Norway. Compared to Gone Green, higher demand in Slow Progression results in higher imports. These are met through higher LNG and Continental imports.

Imports in Gone Green are not materially higher than today as the decline in UKCS is comparable to the decline in demand. Due to the need for some capacity, probably CCGT, to cover for wind intermittency, reduction in peak demand for Gone Green is less pronounced, as shown in Figure 35.

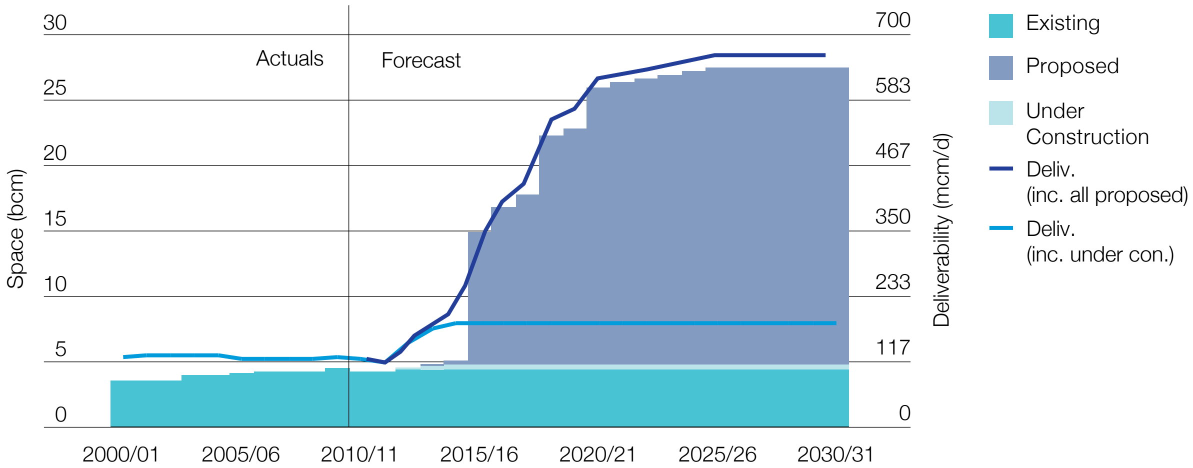
As supplies from Norway decline, Norway could become a provider of peak gas to the UK as existing import capacity will remain. Liberalisation of Continental gas markets (notably access to storage and transmission) could enhance these opportunities.

Unless new LNG facilities are built, supply flexibility from LNG could be reduced due to the need to operate close to peak flows for much of the time.

Whilst the annual position looks manageable, the peak position is expected to become increasingly challenging due to the options for peak supply (more storage, LNG, Continental imports, possible Norwegian swing) and day to day and within day variations in demand caused through the intermittency effects of increased wind generation. All of this will require a network than can readily respond to increased supply and demand changes.

To assess peak supply, the contribution from storage combined with UKCS and all imports at maximum supply / capacity needs to be assessed. As in previous years, the storage position is dominated by the potential for new storage projects that could be built over the next few years. Most of these are projects that are proposed rather than consented or under construction. Those under construction tend to be facilities with high injection and withdrawal rates relative to their space. This enables them to operate relatively flexibly and cycle within winter.

Figure 34.
Storage projects



Whilst the increase in storage space brought about by projects under construction is modest at about 0.4 bcm (less than a 10% increase in space), the resultant total storage deliverability could nearly double to approximately 200 mcm/d.

To avoid ‘picking winners’ no new storage projects are assumed in either Slow Progression or Gone Green. Opportunities for new storage do however exist, for example, to manage the increased demand variation brought about by more wind generation or to provide cover for supply losses. Due to increased supply concentration at entry terminals and the length of the supply chain, these are expected to increase and have a potential greater impact.

The following two charts show the peak supply forecasts for Gone Green and Slow Progression.

Figure 35.
2011 Peak supply forecast: Gone Green

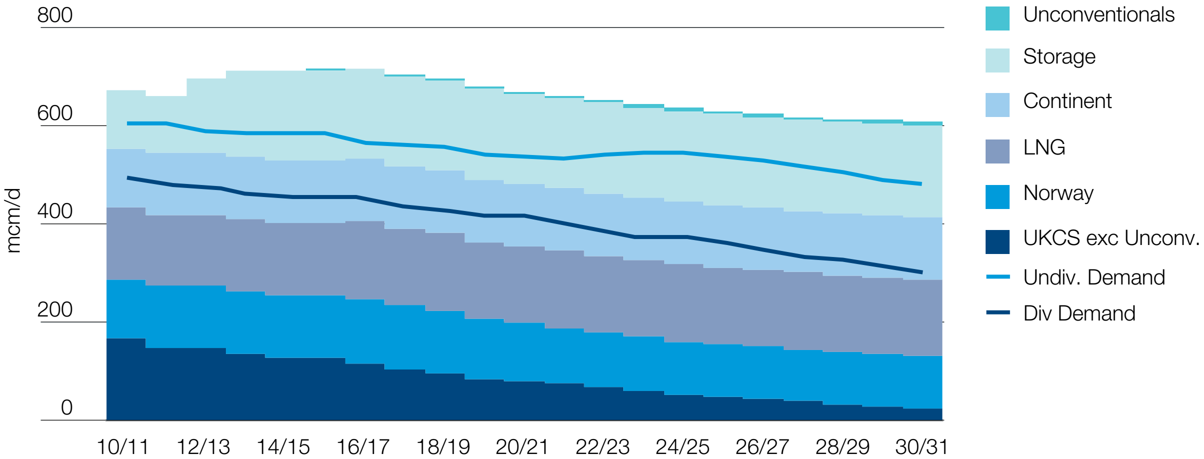
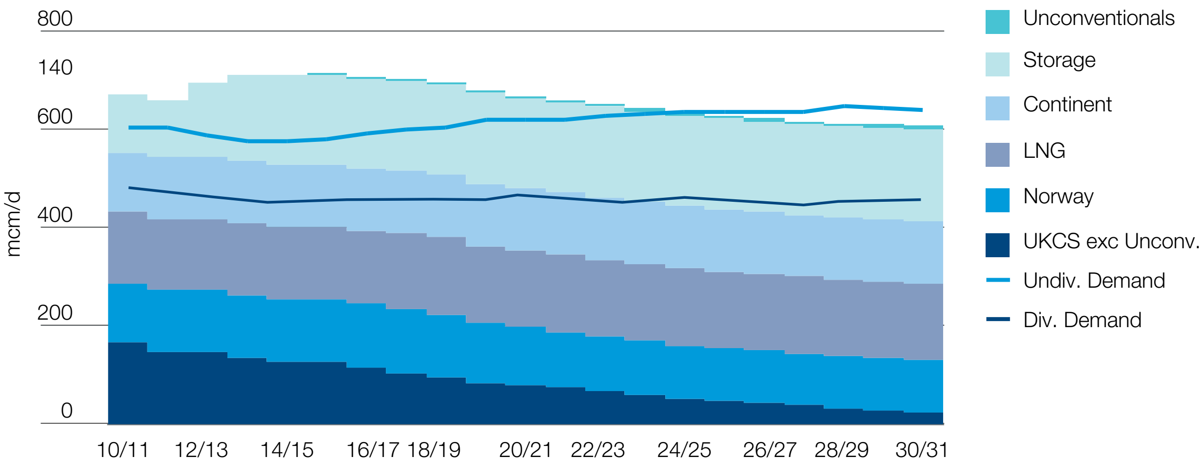


Figure 36.
2011 Peak supply forecast: Slow Progression



These charts potentially overstate the role of imports as all imports are shown at capacity and possibly understate the contribution of storage as storage is limited to existing and storage projects under construction.

Chapter three
2030-2050

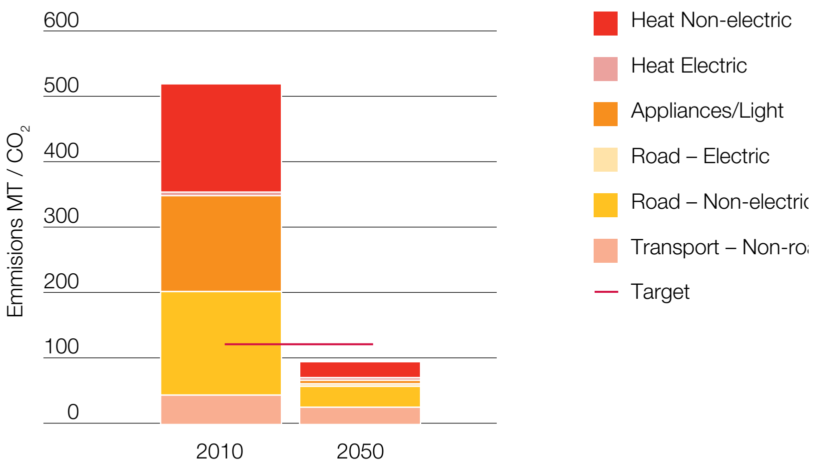
Beyond 2030 it becomes less credible to model scenarios in the same level of detail as in earlier years. Of our scenarios, only Gone Green goes beyond 2030.

3.1
CO_2 target

The Climate Change Act requires a reduction of 80% in overall greenhouse gas emissions relative to 1990 levels4, which is equivalent to a 90% reduction in CO_2, with international aviation and shipping excluded.

Note: Transport non-road includes aviation, national shipping and rail Figure 37 shows CO_2 emissions in 2010 and as modelled in Gone Green in 2050. Note that emissions for each of the three main sectors, heat, electricity and transport in 2010 are higher than the target for 2050, which is one reason why Gone Green requires reductions across all sectors.

Figure 37.
Emissions by sector, 2010 and 2050



Note: Transport non-road includes aviation, national shipping and rail

3.2
Different approach to modelling

Post 2030 the Gone Green scenario has been modelled using a carbon optimisation model. This approach assumes that a high carbon or fossil fuel price drives investment in low-carbon alternatives and that all low-carbon sources get used before higher carbon sources are required.

This approach can also benefit from hybrid heating and transport systems so at times of low demand and high renewable (wind) generation more transport and heat will be electrified than in the converse situation. The levels of electricity going to heat pumps and electric vehicles are however limited by following the same trends seen in the build up to 2030.

3.3
Economic background

By 2050 the UK has transformed into a low-carbon economy with significant reductions in fossil fuel use for electricity generation, heating and transport with the latter two delivered by a significant electrification process.

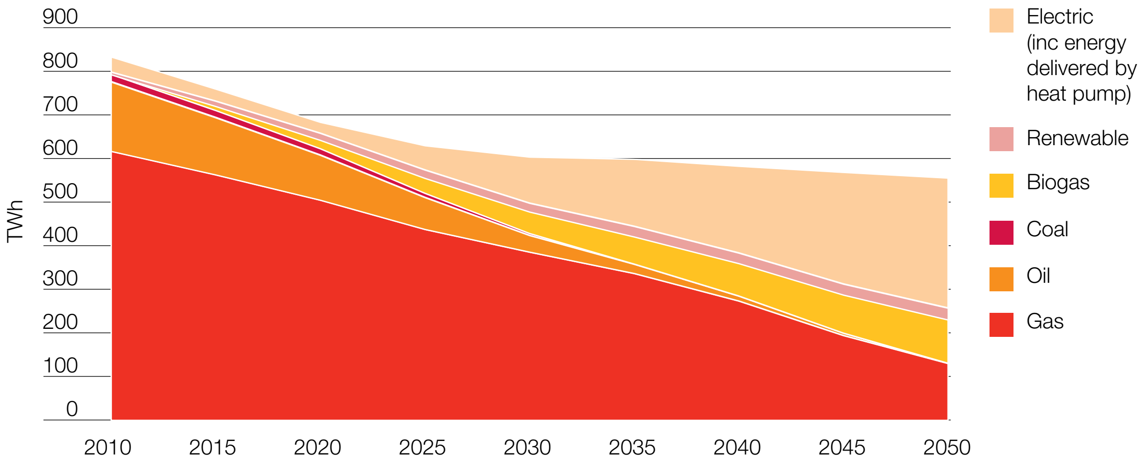
Peaks and troughs in the supply and demand are managed by better interconnection, shared storage facilities and smart appliances which allow for demand reduction of electricity from white appliances, water heating, plug-in hybrid vehicles and potentially space heating in well insulated houses or from those who have access to more than one heating source. Bio resources have made a significant penetration into the heat and aviation market.

3.4
Heat

Heat requirements by 2050 are smaller than today and supplied by a much changed mix of sources. Overall supply has reduced by 30% due to improved insulation, appliance efficiency and process efficiency despite the increase in household numbers and industry output.

As shown in Figure 38, heat is now supplied primarily with heat pumps for base load heat in newer properties, although in older properties which are trickier to insulate, it is still more cost effective to use gas/biogas to cover the large range of hating demand. There is some solar thermal and community scale biomass heating systems in areas where the gas grid is not available. Coal and oil have been largely eliminated other than where they are required for providing high temperature heat within industrial processes.

Figure 38.
Heat supply, 2010 to 2050

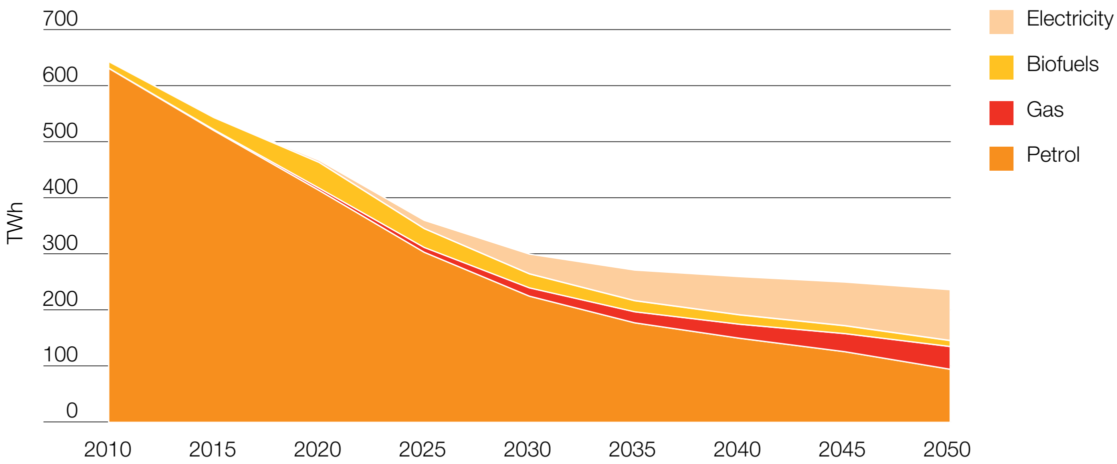


3.5
Transport

Transport by cars and light vehicle transport is dominated by electric and plug-in hybrid electric vehicles with 70% of miles travelled by this sector being met using electricity. Larger freight loads are met using a combination of gas and petroleum hybrid vehicles with gas trucks being used by operators with larger fleets where the price of carbon means converting to gas makes economic sense. Figure 39 shows fuel use in road transport from 2010 to 2050.

Aviation demand is similar to today's, even though people are flying more, but the combination of improved aircraft efficiency, better (straighter) flight paths and better fleet operations along with a 20% mix of biofuels in the engines means emissions have dropped by 20% from this sector.

Figure 39.
Fuel use in road transport, 2010 to 2050

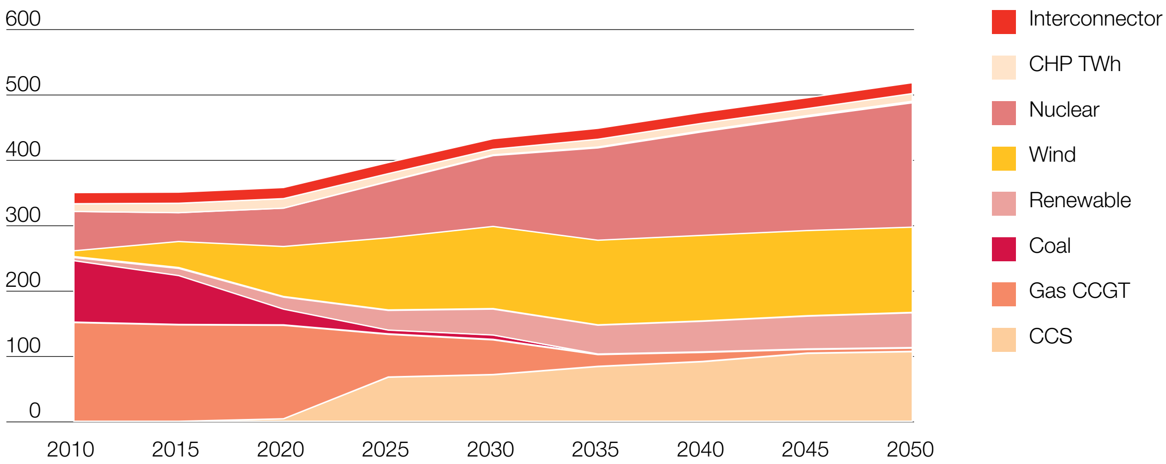


3.6
Electricity

Due to electrification of large portions of the heat and transport sectors, electricity generation has increased by over 50% from today as shown in Figure 40.

Electricity generation is supplied in a balanced way split between nuclear, Carbon Capture and Storage (CCS) and renewable (largely wind) with some OCGT providing demand response to cope with renewable energy fluctuations.

Figure 40.
Electricity generation by type, 2010 to 2050

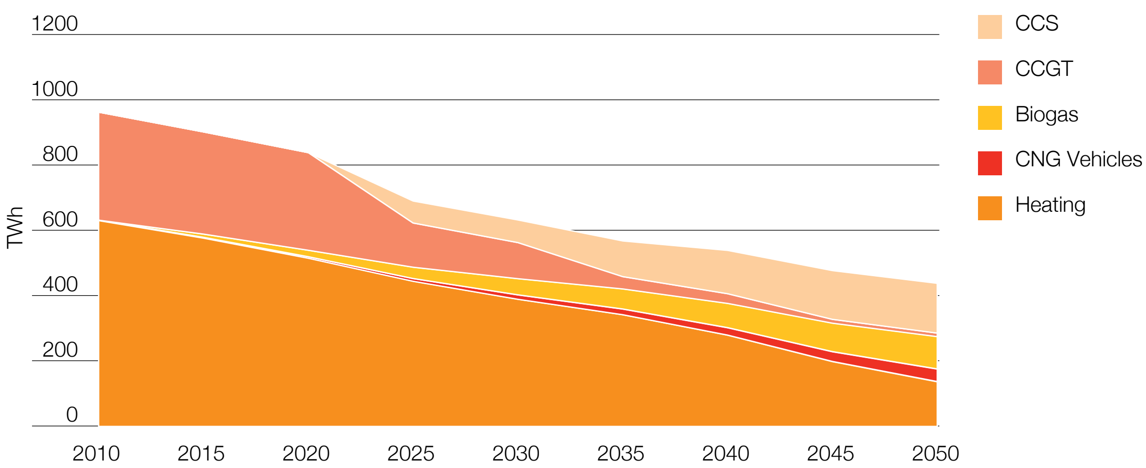


3.7
Gas

Overall gas usage is less than half of today's and is primarily used for power generation (with CCS), high temperature heat in industry, and as a peak heating/balancing fuel.

Gas heating for homes and businesses has declined by two thirds from today's levels with over a third of the remaining gas used being synthesised from sustainable sources.

Figure 41.
Gas demand by end use, 2010 to 2050



UK Future Energy Scenarios
November 2011

Appendix
Key facts

This appendix contains a selection of key facts for each of the three scenarios. As the scenarios have been created in different ways the same data are not always available in all cases, for example Slow Progression data are all for GB rather than UK and Slow Progression has no value for total heat demand, total transport demand, or total energy demand.

Table 1 shows the progress towards renewable and carbon reduction targets at the end of 2010. More recent data are also shown where available.

Table 2 contains data for the Gone Green scenario. Table 3 and Table 4 contain data for Slow Progression and Accelerated Growth where available, but clearly show where equivalent data are not available.

Table 1
Progress towards renewable and carbon reduction targets

Electricity	2010	Latest
Renewable generation	25.7TWh[22]	
Renewable %	7.4%[22]	
Carbon Intensity	496 g CO_2/kWh[23]	
Renewable Capacity	9.2GW[22]	
Wind Capacity Offshore	1.3GW[22]	1.5GW (November 2011)[24]
Wind Capacity Onshore	4GW[22]	4.2GW[24]
Nuclear Capacity	10.8GW	
Interconnector	3.7GW	
Solar PV	77MW[22]	225 MW installed in 9 months to September 2011
Heat		
Renewable	1.8%[22]	
Heat Pumps domestic	28,000[26]	
Heat Pumps non-domestic	8,500[26]	
Solar Thermal	1TWh[22]	
Households	26.9 M[27]	
Transport		
Electric Vehicles	1,500[28]	937 registered in 9 months to September 2011[29]
Renewable %	2.9%[22]	
Total Energy		
Renewable %	3.3%[22]	
CO_2 (excl aviation)	491 MT[30]	

22 www.decc.gov.uk/assets/decc/11/stats/publications/energy-trends/2076-trendsjun11.pdf
23 www.theccc.org.uk/reports/3rd-progress-report
24 www.bwea.com/statistics/
25 www.decc.gov.uk/en/content/cms/consultations/fits_comp_rev1/fits_comp_rev1.aspx
26 www.decc.gov.uk/assets/decc/11/meeting-energy-demand/renewable-energy/2167-uk-renewable-energy-roadmap.pdf
27 www.communities.gov.uk/housing/housingresearch/housingstatistics/housingstatisticsby/householdestimates/livetables-households/
28 www.dft.gov.uk/statistics/tables/veh0203
29 www.smmt.co.uk/2011/10/ev-and-afv-registrations-september-2011
30 www.decc.gov.uk/assets/decc/Statistics/climate_change/1515-statrelease-ghg-emissions-31032011.pdf

Table 2
Key facts for Gone Green

Electricity	2020	2030
Demand	392TWh	446TWh
Renewable %	31%	48%
Carbon Intensity	222g CO_2/kWh	48 g CO_2/kWh
Capacity Trans/Embed/Total	101GW / 14GW / 115GW	128GW / 19GW / 147GW
Renewable Capacity	36GW: including hydro	64GW: including hydro
Low Carbon Capacity	48GW	94GW
Low carbon Gen %	57%	91%
Wind Capacity	17GW offshore 11GW onshore	38GW offshore 13GW onshore
Nuclear Capacity	12GW	17GW
CCS Capacity	0.6GW coal; no gas	6GW coal, 7GW gas
Interconnector	7.6GW	7.6GW
Solar PV	1GW capacity; 0.8TWh	6GW capacity; 4.9TWh
Electric Vehicles	4TWh 1.8M vehicles	40TWh 13.5m vehicles
Heat Pumps	Net decrease; increase due to heat pumps is more than offset by loss in resistive heating	
Heat		
Demand	605TWh (gross CV)	571TWh (gross CV)
Renewable	72TWh	211TWh
TWh & %	12%	37%
Biogas	20TWh	50TWh
Heat Pumps domestic	6TWh from 1.2M households	60TWh from 8M households
Heat Pumps non-domestic	15TWh	55TWh
Solar Thermal	4TWh from 2M homes	8TWh from 4M homes
Other Renewable	26TWh (biomass boilers 18, CH 3 & CHP 5)	38TWh (biomass boilers 21, CH 7 & CHP 10)

	2020	2030
Households	29 Million	31 Million
Transport		
Demand	554TWh (with aviation capped)	460TWh (with aviation capped)
Electric Vehicles	4TWh from 1.8M vehicles 17% of new car sales	40TWh from 13.5m vehicles 76% of new sales
Biofuel	8% surface transport 37TWh	43TWh
Hydrogen	None	None
Aviation	90TWh (capped from 194TWh)	86TWh (capped from 221TWh)
Renewable %	7%	10%
Emissions	108 MT CO_2	88 MT CO_2
Total Energy		
Demand	1471TWh (net CV)	1402TWh (net CV)
Renewable	232TWh	474TWh
Renewable %	15% (net CV)	33% (net CV)
CO_2 (excl aviation)	355 MT CO_2 (-40%, Target -37%)	228 MT CO_2 (-62%, Target -60%)
CO_2 (incl aviation)	403 MT CO_2 (-34%)	281 MT CO_2 (-54%)

Note: generating capacity totals are all for GB;
i.e. excluding Northern Ireland

Table 3
Key facts for Slow Progression

Electricity	2020	2030
Demand	GB only; not comparable with Gone Green	
Renewable %	23%	33%
Carbon Intensity		
Capacity Trans/Embed/Total	96GW / 11GW / 107GW	110GW / 14GW / 123GW
Renewable Capacity	26GW: including hydro	41GW: including hydro
Low Carbon Capacity	38GW	59GW
Low carbon Gen %		
Wind Capacity	10GW offshore 11GW onshore	17GW offshore 12GW onshore
Nuclear Capacity	4 GW	10GW
CCS Capacity	0.6GW coal; no gas	6GW coal, 5GW gas
Interconnector	7.6GW	7.6GW
Solar PV	0.4GW capacity; 0.3 TWh	0.6GW capacity; 0.4TWh
Electric Vehicles	0.9TWh 0.7M vehicles	12TWh 4.5M vehicles
Heat Pumps	Net decrease; increase due to heat pumps is more than offset by loss in resistive heating	
Heat		
Demand		
Renewable		
TWh & %		
Biogas		
Heat Pumps domestic	0.8TWh from 0.4M households	0.8TWh from 0.4M households
non-domestic		
Solar Thermal		
Other Renewable		
Households	29 Million	31 Million

	2020	2030
Transport		
Demand		
Electric Vehicles	0.9TWh 0.7M vehicles	12TWh 4.5M vehicles
Biofuel		
Hydrogen		
Aviation		
Renewable %		
Emissions		
Total Energy		
Demand		
Renewable		
Renewable %		
CO_2 (excl aviation)		
CO_2 (incl aviation)		

Note: generating capacity totals are all for GB;
i.e. excluding Northern Ireland

Table 4

Key facts for Accelerated Growth

Electricity	**2020**	**2030**
Demand	392TWh	446TWh
Renewable %		
Carbon Intensity		
Capacity Trans/Embed/Total	117GW / 14GW / 131GW	137GW / 19GW / 156GW
Renewable Capacity	51GW: including hydro	74GW: including hydro
Low Carbon Capacity	58GW	100GW
Low carbon Gen %		
Wind Capacity	33GW offshore11GW onshore	50GW offshore 13GW onshore
Nuclear Capacity	6GW	15GW
CCS Capacity	0.6GW coal; no gas	6GW coal, 5GW gas
Interconnector	7.6GW	7.6GW
Solar PV	0.8TWh	4.9TWh
Electric Vehicles	4TWh 1.8M vehicles	40TWh 13.5M vehicles
Heat Pumps	Net decrease; increase due to heat pumps is more than offset by loss in resistive heating	
Heat		
Demand	605TWh (gross CV)	571TWh (gross CV)
Renewable	72TWh	211TWh
TWh & %	12%	37%
Biogas	20TWh	50TWh
Heat Pumps domestic	6TWh from 1.2M households	60TWh from 8M households
non-domestic	15TWh	55TWh
Solar Thermal	4TWh from 2M homes	8TWh from 4M homes
Other Renewable	26TWh (biomass boilers 18, CH 3 & CHP 5)	38TWh (biomass boilers 21, CH 7 & CHP 10)
Households	29 Million	31 Million

	2020	2030
Transport		
Demand	554TWh (with aviation capped)	460TWh (with aviation capped)
Electric Vehicles	4TWh from 1.8M vehicles	40TWh from 13.5M vehicles
	17% of new car sales	76% of new sales
Biofuel	8% surface transport	
	37TWh	43TWh
Hydrogen	None	None
Aviation	90TWh (capped from 194TWh)	86TWh (capped from 221TWh)
Renewable %	7%	10%
Emissions	108 MT CO_2	88 MT CO_2
Total Energy		
Demand	1471TWh (net CV)	1402TWh (net CV)
Renewable		
Renewable %		
CO_2 (excl aviation)		
CO_2 (incl aviation)		

Note: generating capacity totals are all for GB;
i.e. excluding Northern Ireland

- Values are the same as Gone Green
- Values are different from Gone Green

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